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M51

THE

GEOLOGICAL

AND

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OF

MINNESOTA.

SIXTEENTH ANNUAL REPORT

FOR THE YEAR 1887

Plates, one Map and Eighty-eight Other Illustrations.

N. H. WINCHELL, STATE GEOLOGIST.

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ADDRESS

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, March 20, 1888.

To the President of the University:

DEAR SIR: I have the honor to present herewith a report giving the results of the work of the geological and natural history survey of the state for the past year, so far as it is possible to put them into shape for publication. Investigations are being carried forward in the lithology of the crystalline rocks and in the palæontology of the fossiliferous ores, which are not as far advanced as to warrant report.

Respectfully submitted,

N. H. WINCHELL,

State Geologist and Curator of the General Museum.

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in the laboratory and museum and office. He has given his spare time to the examination of the insects of the state.

Mr. Arthur was not engaged in botanical work owing to the exactions of other professional engagements which he had to meet.

Mr. Ulrich resumed in September his work on the bryozoa of the Silurian, and has been engaged on them ever since.

In my absence from home my wife has attended to the reading of proof, both of the final and of the annual reports, and to my correspondence.

At the request of Mr. Herrick that portion of his manuscript which he had submitted was returned to him for revision and completion. He has since returned it in final readiness for publication. I have also received a statement from Dr. P. L. Hatch that his report on the birds of the state is ready and will be furnished at any time on a few days' notice. He desires to retain it for the purpose of entering the latest observations.

The specimens belonging to the museum have increased at the usual rate, and a report on the accessions is herewith submitted.

Several American and foreign societies have begun to send their proceedings and reports to the survey—indeed some have done it for several years, but recently the number has increased. These scientific works are of a strictly technical character and should be preserved to form a collection for the use of the scientific professors of the university The collection will be augmented from year to year as the publications of the survey are extended.

II.

REPORT OF N. H. WINCHELL.

In the month of July, a party was organized to make reconnoissance of the area of the original Huronian on the north shore of lake Huron, of the iron-bearing rocks of the Marquette range, in Michigan, and of the Gogebic and Penoke ranges in Wisconsin. The results of observations made during these reconnoissances will be given briefly, since they have a direct bearing on the stratigraphy of the rocks of northeastern Minnesota. Following this will be given further descriptive notes and diagrams of the geology of the crystalline rocks in the northeastern part of Minnesota.

THE ORIGINAL HURONIAN.

Bruce. At the Wellington mines, and also at the old Bruce mines about a mile further east, the country rock, so far as seen, embraces only eruptives.[*] The mines themselves consist of excavations in quartz veins, or in old fissures in the country rock filled and cemented by quartz and embracing many fragments of the wall-rock. These veins run in various directions, but those which were worked for the copper sulphuret run about N. 15° W. (mag.).[†] The aspect of these veins, and of this "dioryte," is like that of the formation seen at Silver Islet on the north side of lake Superior; the sulphide ore here being copper and there silver galena.

The rock No. 1149 represents large areas of this dioryte at this place. It is found at the village of Bruce, and in front of the old Wellington stamp-works. It has when weathered a finely specked surface, due to the whitening of the crystal grains of the plagioclase. It is heavy, dark or greenish-gray within, massive, mainly without any bedding structure but occasionally rudely sheeted like overflow eruptives, jointed in all directions, apparently identical with much rock that accompanies the black slates on Pigeon river in Minnesota. The fineness of its grain varies sometimes gradually, and sometimes suddenly. Rock 1150 which seems to be only a finer grained, even aphanitic, variety of 1149, occurs in narrow dykes and in patches in it, evidently eruptive in the coarser dioryte.

---

[*] My brother, however visited an outcrop of "limestone" a little northwest from the old Wellington location, and at a mile and a quarter northeastward black slates were seen having apparently a high dip toward lake Huron,

[†] According to the small atlas accompanying the Canadian Geological Survey report (1863) the variation of the needle at Thessalon, on the authority of Mr. Salter, is about 4° to the west.

Crossing rock 1149 occurs a great dyke, running nearly N. and S. rising near the lake shore and extending onto the hills in the village. This dyke, represented by rock No. 1151, is composed apparently of the same ingredients as rock 1149, but the grains are finer, and the rock much darker and heavier.

Thessalon, Ontario. Considerable careful observation was made at this typical Huronian locality. At the mouth of the river both shores were seen to be composed of the same rock as above described at Bruce, especially in its coarser parts. It is grayish to dark, often with a greenish tint. It commonly presents a speckled weathered surface, owing to the decay of the feldspar grains which are thickly crowded among the augites, but it graduates into finer-grained rock which again passes into very fine-grained, nearly black rock. The following samples illustrate this:—

1152. Very fine-grained, sometimes aphanitic and nearly black.

1153. Coarser-grained, speckled on the weathered surface.

1154. Coarser-grained, speckled on the weathered surface.

1155. Medium-grained, and somewhat speckled with porphyritic feldspar, also with a reddish vein of granulyte.

These samples were obtained at the mouth of the Thessalon river. on the right bank. The rocks from which these samples are derived all grade into each other here in short intervals. To this point considerable observation was given. There is a confusion of strike, or what might be considered strike, the directions being seen only in short spaces, indicating either that there has been a breaking of all the structures and a recementing, or an original molten state, with considerable irregularity of flow.

On the left (eastern) bank of the river, near the lake, is a large surface exposure of similar rock, extending along the lake shore for some distance eastward, and also inland toward the northeast, its full extent not being ascertained. The rock here varies in bands and wide irregular belts, with beautiful glaciation. It changes abruptly in its direction of trend, and it rises and falls in low hillocks that are separated by swamps or by standing water. On the east side of the river, at the lake shore, much of the rock is rather fine-grained and diabasic, resembling much of that seen in 1886 on the Kawishiwi river.

Rock 1156 represents this fine-grained, dark rock from the east bank at the mouth of the Thessalon river. There is here, over the surface, a weathered green of a lighter color (1156 A) than any green seen within the rock, and in patches an abundance of epidote; also some pyrite and chalcopyrite.

Patches of "conglomerate" also appear on the glaciated surface, the pebbles being apparently of the same kind of rock, and rounded. No continuous dip can be seen, but there is occasionally a slaty disintegration which dips about 45°, but veers round so as not to be long continued and fades out. It has a prevailing direction (on the east side of the river) when seen, a little south of southwest. Sometimes this rock varies to a massive, homogeneous, firm, dark-greenish-gray, diabase-looking rock, like some seen in the railroad cut near Thompson, Minn., represented by 1157. It contains, like nearly all the rock here, very little if any free quartz. In other places are seen angular and also vein-like patches of rock apparently permeated with epidote represented by No. 1158, obtained from the east side of the river.

About half a mile east of the river, and perhaps an eighth of a mile from the lake, the surface of this eruptive rock is banded with pitted and non-pitted belts (1159). These belts undulate and vanish. Within the rock these pits are found to be filled with delessite. They are soft, give a light soapy streak though dark green when weathered. They vary from the size of pin-heads to the size of beans. In other places again these amygdaloidal pits are distributed generally and not in bands.

Instead of being chloritic these spots sometimes are filled with a harder mineral, rather siliceous, that weathers red (1160), like some of the mineral vein matter seen in 1155, and recalling the reddish substance in the felsitic dike seen near the lighthouse at Marquette. These amygdule-like forms are not due to the dissemination of pebbles in the rock from sedimentary action. They are all of the same nature, and sometimes, especially in the case of the delessite-filled cavities, they exhibit, when broken across, a radiated and fibrous structure, and a layering of concentric superposition as if they had grown up after the manner of geodic filling in pre-existing cavities. Further examination also revealed that the delessite-filled cavities become elongated downward, attaining three and a half inches in length, on the perpendicular face of the broken bluff. They rise from a common stratum which looks as if it were their source. Judging by the general appearance and the direction of these tubes where they can be measured, others must be six or eight inches in length, though visible only at their openings on the surface. They are about a quarter of an inch in diameter, varying to an eighth of an inch, presenting somewhat the appearance of *Scolithus*. Thus their forms vary from round amygdules to tubes six or eight inches in length. When elongated they must have served as ducts for escaping gas rising from some sulphureted or carbonated stratum. There is, however, now no sign of any such stratum. That from which they issue, or above which they ascend, is like all the rest of the rock, but varies in the weathering colors according to the fineness of the grain. A good photograph was obtained of this structure. (See fig. 1, pl. I).

It is apparently due to the enlargement and multiplying of the reddish felsitic amygdules, locally, and the specialization of the mineral ingredients into macroscopical crystals, that patches of red rock are produced in this greenstone. No. 1161 represents such red rock. Such patches are sometimes four, or even eight feet square, scattered capriciously about, visible on the glaciated surface of the dark rock. This red rock consists apparently of quartz and orthoclase in distinct crystals, embracing in their interstices a greenish to black, soft substance that, while finely foliated and resembling chlorite, yet does not seem to have served any other purpose than to occupy the vacancies between the other minerals as they assumed their crystalline shapes. Such nodules and veinings, if not such isolated large masses of reddish granulyte in trap rock, are not very uncommon. They occur at Taylor's Falls and at Duluth, and have been described by the writer at several places in northeastern Minnesota. Since the basic eruptives, when in their normal state, do not embrace the minerals here differentiated within them, it may be presumed that these exceptions are caused by the local and superficial mingling of small portions of the siliceous super-crust with the heated basic eruptive. On cooling and weathering the super charge of siliceous matter is rejected from the mass and is compelled to fill any convenient veins or amygdaloidal cavities that are within reach. When none such are found these crystals are formed within the greenstone and are uniformly disseminated in it, causing the well-known quartz-dioryte and orthoclase-gabbro.

These rocks are denominated "green chloritic slates" in the Canadian survey reports, and are also so designated on the geological map of the region accompanying the general atlas in 1863.* On account

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* Geological survey of Canada; report of progress from its commencement to 1863. Atlas of maps and sections, 1865.

Plate I.

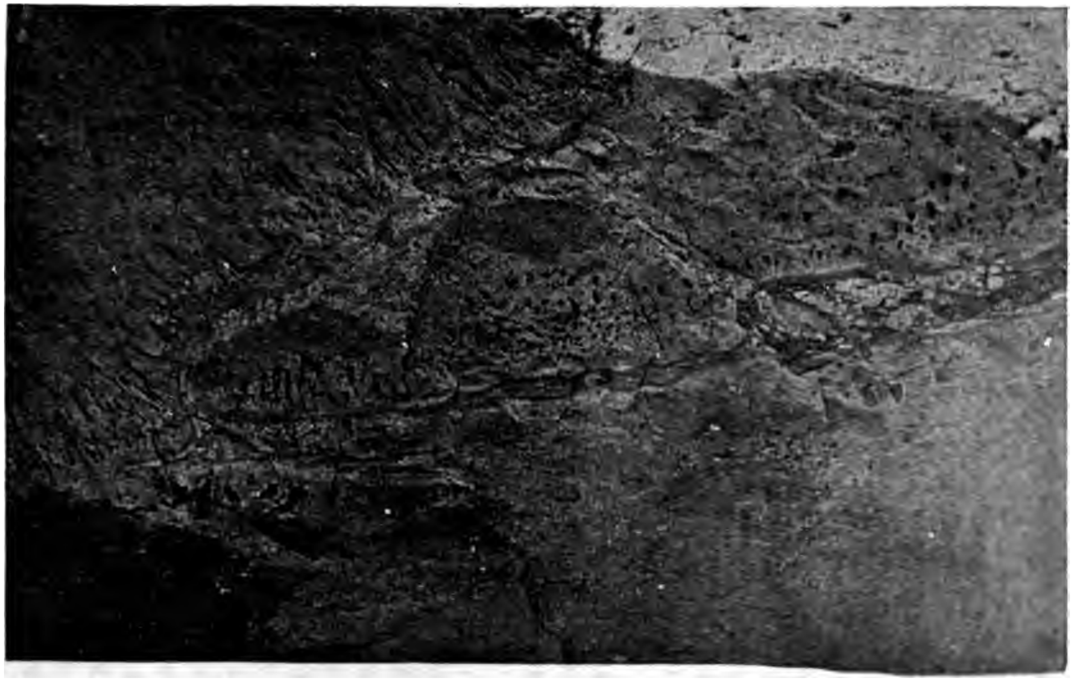

Fig. 1.—*Amygdaloidal structure in the "Green Chlorite Slates."* *Thessalo*

of this fact a careful inspection was made, at all places about the mouth of the Thessalon river, in order to ascertain if any part of the visible rock surface would appropriately bear that name. Besides this place the Canadian map of this region shows the same rock at but one other locality; that is about thirty miles toward the northwest, in a small area at the extreme north end of Echo lake. The only point at which any slaty structure that would warrant the use of the term "slate" was found, is on the point on the west side of the river, but near the mouth of the river. Here are some thinly parted portions which resemble hardened crumpled black slate. That is to say, the rock parts, on the weathered exterior at least, into fissile, schisto-slaty beds about one quarter to one eighth inch in thickness, the strike and dip of which are pretty regular and uniform for about ten or twenty feet. This schistose slatiness appears on the face of a low nearly perpendicular bluff facing toward the lake, and near the lake level. The dip is north, 30° W. (mag.) and about 40° from the horizon. In the seams are minerals that result from change in diabase—chlorite and epidote—these giving a resemblance to banding and striping similar to that seen in some places in the rock already described on the east side of the river. In other places adjacent the dip is in other directions. Distinctly amygdaloidal patches are seen in this fine-grained portion, not far removed from the slaty portion, but not in the slaty. In weathered surfaces the slaty portion, under the hand-glass, exhibits no free quartz, but a gray surface of plagioclase.

Examining more broadly in the vicinity of this slaty exposure, in an area of several rods round about, on nearly all of which the surface is bare rock, it is seen that a part of the rock on the west side of the river (where it is fine-grained and also where it exhibits this slaty disintegration) is set off from the other part by an invisible dividing line, the surface being lichen-covered and hummocky. The rest is speckled with fine porphyritic feldspar crystals, as seen and described in 1153 and 1154, and is undoubtedly the equivalent of the great greenstone formation of the region seen at Bruce and on the east side of the river at Thessalon, and in the ridges that cross the river further inland. The line on the weathered surface separating these two parts is partly imaginary, and partly vanishes when sought for, since the characters of one rock are found in patches further north or south than they belong if there be genetically two rocks here, each rock transgressing the boundary that may be supposed to have limited it. These patches seem not to be easily separable from the surrounding rock by any line of demarkation in the lithology, but there is, at least in nearly all cases, a gradual change in the grain so that the full transition is effected in the space of from one to three inches. Indeed these different rocks, from one of which is produced the slaty-fissured rock mentioned, appear to be phases only of the same rock. It is hence probable that the slatiness mentioned is caused by an original flowage structure, in the laminæ of which on partial decay, were accumulated in greater amount those minerals that easily decay, in regular alternation with those that do not, and that possibly the internal grain was affected by thin sheets of finely amygdaloidal rock alternating with non-amygdaloidal. The exposed position of the little bluff would account for the conspicuous development of the slaty structure by increased decay, on the lakeward side. This slaty rock is represented by 1173.

If still this slaty phase should prove, after further study, to be due to the existence of a fragment of a once sedimentary rockmass in the midst of the eruptive, it can only be assigned to some part of the black slates of the region. It is not green within, but gray to nearly black. It is fine-grained and difficult to specifically name without microscopic and chemical examination.

About a mile northwest from the village of Thessalon, on the west side of the main road, and on the west side of the river, is a light-weathering ridge of quartzyte. It runs S. 30° west (mag.) and appears on the lake shore a few miles west of the mouth of Thessalon river. It rises at once about thirty or forty feet above the highway, and higher still at a little distance further west. This rock is represented by 1162, a gray quartzyte dipping in general N. 45° W. (mag.); but it varies to nearly white on weathered exposures, and to light red where fires have prevailed. It shows an incipient gneissic structure. It has been broken and crushed together and recemented. Its dip varies in direction in short intervals, and is even cut off squarely by a structure of a different sort, but all closely cemented together. In the vicinity of a dike forty feet wide, that runs N. 60° W. (mag.) cutting this rock, this quartzyte shows suggestive variations. Its color and texture, while principally quartzose, yet seem to manifest a felsitic or a feldspathic tendency developed in it. Compare rock No. 1163. This tendency is marked in that part of the quartzyte which is embraced between two forks where the dike separates, and close in the angle between them, where also a longitudinal close jointage is developed on weathering, resembling slatiness. The dike (1164) consists of rock like the eruptives described at the mouth of the Thessalon river. (See figure 1.)

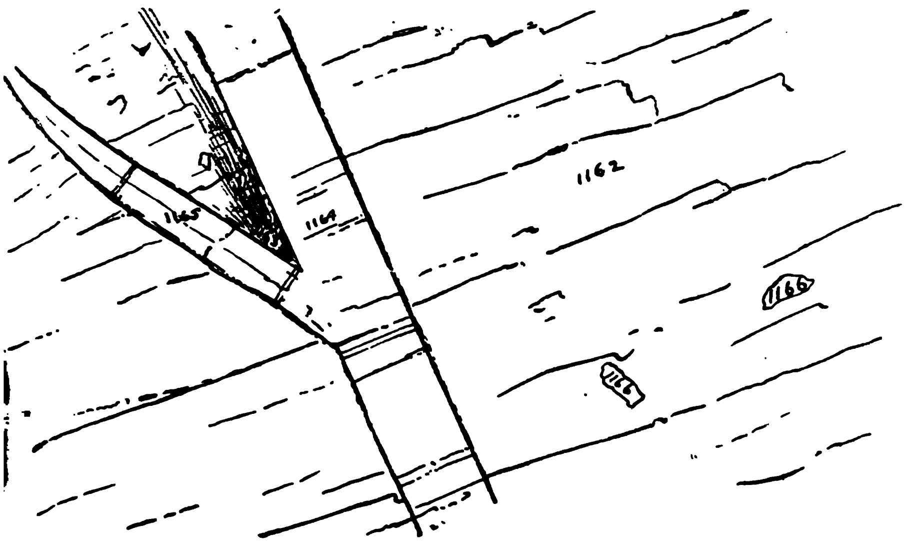

Fig 1.—*Spur of gray quartzyte enclosed between the forks of a branching dike, changed to red felsyte and gneiss.*

In the mass of the quartzyte can be seen the original banding of sedimentation, and also the "false bedding" that is common in sandstones running at different angles. There are also patches of considerable size, apparently produced by boulder masses involved in the sedimentary process at the time of accumulation, somewhat discordantly disposed in the bedding, some of which are of quartzyte similar to itself, and others are of a greenish rock, somewhat serpentinous by decay, but plainly of an eruptive nature and origin before it was embraced in the sediments of the quartzyte. Compare 1166. A photograph was made taking in a general view of this quartzyte.

The Thessalon valley is covered by a lacustrine clay which, when cleared for farming, makes a fine wide expanse for crops. The clay is gray. It was deposited when the lake level was at a beach, which is visible, about forty feet above the flat. This beach consists of coarse water-worn stones, on the rock bluff, seen on the west of the road about a mile and a half north from Thessalon on the west side of the river. On the east side of the river it is composed of gravel at some points, but it is generally coarser than gravel.

Westward from this quartzyte ridge runs similarly a conspicuous ridge of dioryte and diabase, illustrated by No. 1167, undistinguishable from the eruptive rock seen at the mouth of the river. This ridge runs toward the lake, and apparently overlies the quartzyte of 1162. It shows an igneous contact running east and west; and at a point at the roadside, where the river flows easterly, a broad uncovered surface of the quartzyte, sloping with the dip northwestwardly, is seen to pass toward the southeast directly under the trap rock of the ridge, the overlie of the trap in a sheet on the quartzyte being immediate and unquestioned. This trap bluff was photographed. (See fig. 10 p. II.)

Traveling a little further west we find the highway crosses the Canada Pacific railroad, and a rock-bluff appears facing southeast, rising about fifty feet, on which is another overlie contact of the diabase on the quartzyte. The quartzyte dips northwest at an angle of about 40° from the horizon. On the right of the exposure the quartzyte is cut off by a contact running nearly vertical, but backward so as to produce a slight overlie of the quartzyte on the diabase, as the plane of the bluff crosses the contact plane. This place is four and a half miles by the road from Thessalon village. This diabase is represented by rock 1167. See fig. 2.

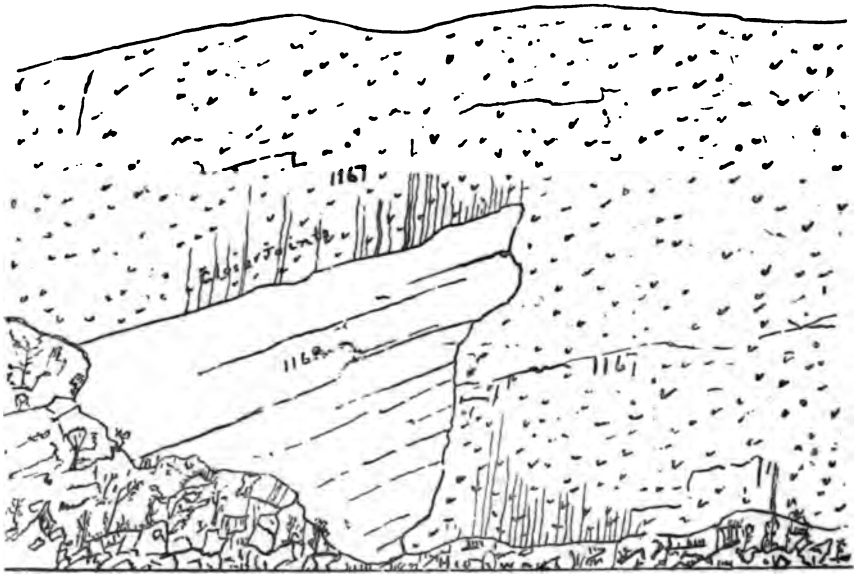

Fig. 2.—*Diabase lying unconformably on quartzyte.*

At Macbeth's bay, about five miles west of the mouth of the Thessalon river, the Canadian Pacific railroad and the highway cross the creek but little above the head of the bay. Here the quartzyte has fine exposures. On both sides of the creek it is cut by dikes of basic eruptive rock, and on the west side it is replaced entirely, over a large area, by an overflow of this rock. This is the same rock as that already mentioned, and is again represented by 1168. It is a coarse diabase, and prevails largely over the country between Macbeth's bay and Thessalon, cutting and overlying the gray quartzyte 1162. It appears as if through fissures in the quartzyte the dark diabase had issued, spreading right and left, according to the continuance of the eruption. This diabase now forms hills and ridges, the chief elevations of the region, mostly having an east and west direction; the quartzyte occupying, where seen, much lower levels.

Sometimes the quartzyte becomes conglomeritic with quartz pebbles (1169), but this is only in small rare spots; and sometimes it is slightly pinkish.

On the road running north from Thessalon on the east side of the river, at about a mile from Thessalon, a fine-grained pinkish quartzyte outcrop appears, rising in the midst of the surrounding hillocks of diabasic eruptive rock. It has an abrupt contact on the greenstone running N. 40° W. (mag.). The quartzyte is closely jointed and very hard and fine, no dip generally being visible, but in places exhibiting a sedimentary banding, which expresses a dip 30° toward the northwest.

At two miles from the mouth of the river, on the east side, the quartzyte appears again, but it is much lighter colored and very fine, almost suitable for honestones. It weathers to a kind of light pea-green color. Glaciation is abundant and fresh, showing the same kind of curving cross-fracture as seen at Thessalon, and on the quartzyte in Pipestone county, Minnesota.

At Little Rapids, three and a half miles north from Thessalon, the highlands are covered by a range of diabase (dioryte?) that runs about N. 80° W. and rises perhaps 100 feet in the vicinity on either side, on the east side having a quartz vein two or three feet wide, and somewhat amygdaloidal near the vein. But the rapids in the stream (Gas creek) are caused by a range of quartzyte that dips about 45° or 50° toward the north (mag.). Some narrow bands in this are pebbly with black jasper (rarely red) and of white quartz, but the great bulk of it consists of the same pinkish to gray quartzyte.

Gray quartzyte rises in the swamp about a mile southeast from the little rapids. This is striped with rare belts of conglomerate, one piece of white quartz being three inches in diameter. But pebbles of this size are rare. The conglomeritic belt in which this lies continues about ten feet. Its direction indicates a strike S. 30° W. (mag.). There are also here pebbles of flint and green chert, and of banded white and black jasperoid rock, also of other kinds of fine-grained rock not silica, but siliceous, which weather to a drab or light buff-color. From this place there seems to be a grand belt of quartzyte that strikes southwestwardly, running under the Thessalon and reaching the lake shore at Macbeth's bay, where it appears on the islands that lie off the coast. The dip is in all cases where it has been seen, toward the N. W.

Traveling from Little Rapids (of Gas creek) north, crossing the creek (at ¼—½ m.), thence west about two miles, having a range of hills on our right and the river on our left, we take the first good opportunity to examine the rocks in this ridge. They are a mingling of diabase and quartzyte, the latter being sometimes red and conglomeritic. The ridge rises about 150 feet above the road where the rock was first encountered not much above the road, it is dark-colored and diabasic, but has spots and veins of red, and even weathers red to the depth of six or eight inches. In ascending the ridge, however, this immediately gives place, upward, to a broken and confused red conglomerate or breccia-like grit, which continues to the top of the hill, the exposure being such that the observer is compelled, in ascending, to travel on the south-dipping upper surface of the stratum.

A short distance further west the southern slope of this ridge shows outcrops of southwardly dipping quartzyte. The dip is about 20° toward the southwest. The direction of the ridge crosses the dip at an angle, so that on the southern slope the strike of the different beds climbs diagonally up the hill toward the northwest, the higher layers being further toward the west. At several points the eruptive rock appears on the southern slope, sometimes near the base and sometimes well up on the hillside, but owing to the dense covering of vegetation there was no opportunity to discover, with our limited time, the relation it bears to the quartzyte, though there is no reason to suppose it is different from that already stated. It seems to have overflowed the upheaved quartzyte and to have been preserved only in the lower levels, particularly so when the accumulation was not in mountain-like hills or ridges.

There is a conspiouous outcrop of this quartzyte and conglomerate near the base of the ridge on the same side showing the same dip conclusively and generally. We examined it first in front of Mr. John Wray's house and followed it westward to opposite Mr. Wm. Ensley's house where this conspicuous outcrop occurs. It is here wholly a siliceous quartzyte, but has a few quartz pebbles running in narrow and interrupted belts through it, coincident with the bedding. It is red but varies to purple, and is vitrified and polished in the same manner as seen on the surface of the red quartzyte in Pipestoue county, Minnesota. Indeed, were we not conscious of being in the area of the original Huronian we might suppose ourselves, so great is the similarity of all the geological features, to be standing on some of the red quartzyte outcrops in southwestern Minnesota.* This red quartzyte in hand samples, represented by 1171, cannot be distinguished from much of that of Pipestone and Watonwan and Cottonwood counties, Minnesota, nor from that of the ridges at Baraboo, Wisconsin. This great quartzyte, so far as can be determined by anything seen in the area of the original Huronian, or even in Wisconsin and Minnesota, whether dipping N. W., N. or S. W., whether white, pink or red, or purple, or pea-green white, whether arenaceous or pebbly, is plainly a unit. It must have a great thickness, for it extends westward from Wray's house with the same dip at least a mile. It is true that this distance is not measured here directly across the bedding, nor on the hypotenuse of a triangle perpendicular to the direction of the strike; but the thickness observed here can be fairly estimated to fall not much short of 5,000 feet, and it may be twice that amount.

At Ansonia P. O. is a place in the river known widely as "the dump." This is in the township of Le Froy. A glaciated surface outcrop of rock may here be seen at the river level, (See fig. 3) on the right bank, immediately overlain by a bank of till. The river flows over it except in time of low water. This rock seems to belong to a different formation, both on account of its different lithological characters and the different direction and amount of its dip. The bedding stands about vertical and it strikes about 30° north of west. The layers are thin, varying from slaty to two or three inches. Much of this rock, while siliceous, weathers to a light drab or even to a buff. It is finely crystalline, at the same time that it is fragmental and banded by sedimentary colors and belts of differing structure. It might be used for lithographic purposes if slabs of sufficient size could be procured. It affords a slow, fine effervescence when hydrochloric acid is applied on a fresh surface. There are here several varieties of rock related as shown in fig. 3.

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*This similarity extends even to the existence of eruptive basic rock in some places among the red quartzyte. According to Prof. J. E. Todd a dioryte outcrop occurs in sec. 15, tp 102—48, about five miles S. SW. from Palisades, in southwestern Dakota. He judged from the dip at several neighboring localities that this dioryte overlies the quartzyte. "The dip of the quartzyte at Palisades is 4°—6° SW. About one and a half miles S.E. from the dioryte, another exposure of the red quartzyte dips 2°—8° N. of E. At Sioux Falls the dip is about 3° S. SW. It may be there is a fault between palisades and the locality but I had conceived the dioryte to have flowed out through and upon the red quartzyte." [*Letter dated Oct. 22, 1885.*]

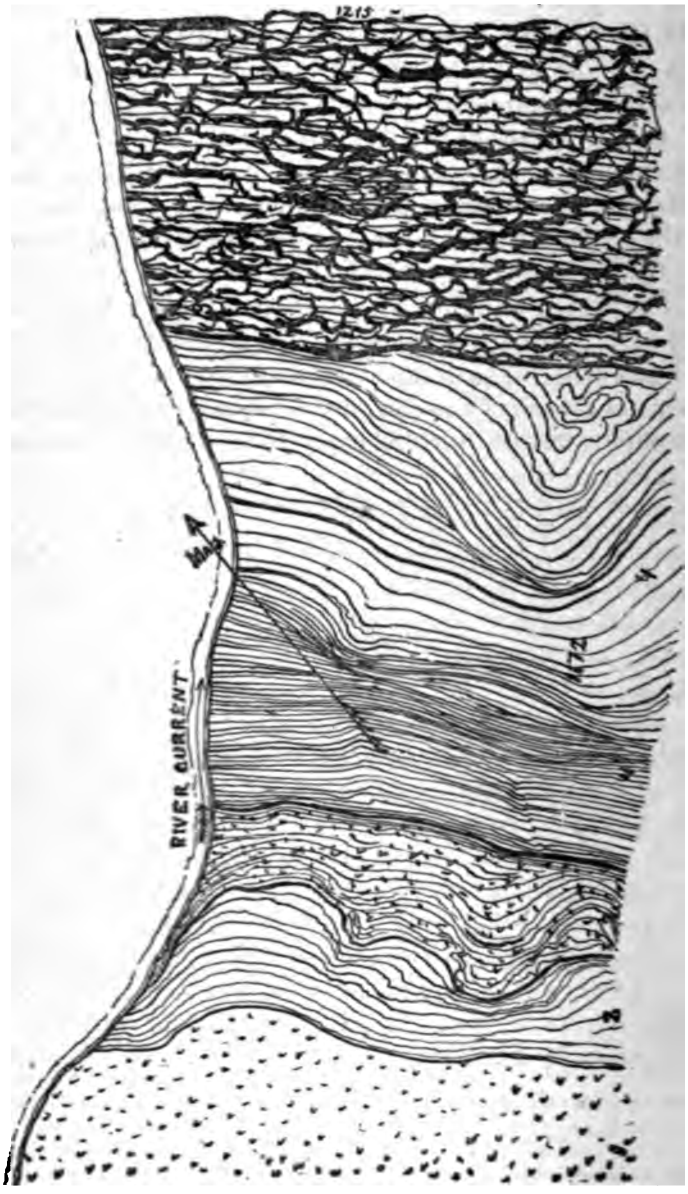

Fig. 3.—*Surface exposure at "the dump."* ***Ansonia P. O.***

Explanation of Figure 3.

1. Fine, diabasic greenstone: width of surface exposure, seen ....10 ft.

2. Fine-grained drab stone, with undulating sedimentary banding (1172): slightly calcareous gray quartzyte or lithographic stone: surface band, about ....2 ft.

3. A greenish, fine-grained, apparently eruptive rock, having a very irregular width, and on the surface marked by interrupted bands and lines that seem to be

the remnant of an original fluidal structure. These fluidal lines are not conformable with those in No. 2. This member varies from....................2 to 3 ft.

4. Rock similar to No. 2, affording a very smooth hard surface, some of it very finely stratified, and some of it confused in its strike, particularly in its eastern portion; width of belt about..20 ft.

5. This member (1215) is the most interesting. Its exterior surface is quite different from No. 4, and on first glance it would be taken for a rotted eruptive, but closer inspection shows that it is a folded, compressed and crushed condition of some of the sedimentary strata belonging in the same category with the others. It is rough and jagged, rather fine-grained, with a felsitic aspect, but darker when wet, much slickensided, has quartz veinings and is rusty with oxydized pyrite. Sometimes, on weathered angles, it appears like a fine felsyte, having a reddish tint and a pseudo-fluidal outward aspect; and in other parts it is apparently a fine, reddish impure quartzyte. In general, it is a hardened part of the slate formation that underlies the great Huronian quartzyte. Surface exposure, width, seen, 15 ft.

Rock No. 1172 (above), seen in No. 4 seems to be allied to the chert-beds, or to some seen near the base of the Animike in northern Minnesota, but it is rather too light-colored and too coarse-grained to be called chert—though it seems to contain the same elements in about the correct proportions. It is a fine-grained, bedded, siliceous, light-gray rock, and seems to have something in it which causes it to become coated with a rust film. It resembles some pebbles seen in the great quartzyte of this region, especially some seen in the quartzyte about a mile southeast from the "little rapids" of Gas creek, already mentioned. Such source for these pebbles would indicate an unconformity between the quartzyte and this thin-bedded formation. If a horizon of rock similar to the Gunflint beds of northern Minnesota exists in this slate and quartzyte formation, nearly all the colored flint pebbles seen in the overlying great quartzyte can be referred to it; and the presence of such pebbles in the quartzyte, other relations being favorable, strongly indicates the existence of such chert and flint beds.

At a mile west of "the dump," on the right of the road, is a low hill consisting of diabase rock. Several hillocks in the immediate vicinity apparently contain the same rock. A vein of red orthoclastic granulyte runs through this rock, represented by 1193. The country about on the south side of the Thessalon is hilly, apparently with ridges and knobs of the same rock.

About sec. 8, Le Froy, south of the Thessalon river, near the highway, between it and the river, is a sloping glaciated surface of the same formation as seen at the water-level at "the dump." It dips northerly at an angle of about 40 degrees, but it is so twisted and broken that no certain statement can be made of its direction. The average strike is perhaps E. 30° N. (mag.). This rock, while belonging to the formation seen at "the dump," is yet less calcareous than that, and has a darker drab color, sometimes being bluish or greenish gray. It is intersected by many quartz veins, some of the quartz being drusy and amethystine, many of them coincident with the bedding. Mingled with the quartz are black scales of a crystalline metallic oxide, which has not yet been determined, thought to be hematite. On weathered surfaces the rock although fine, dense and hard, is coated with a rust-scale which is sometimes a quarter of an inch thick, resembling some rock seen near Gunflint lake. It is not seen to be slaty here at any place, although thin-bedded. Its outward characters resemble the silver-bearing formation seen along the international boundary north of lake Superior. This rock is represented by 1194, and 1194A.

Further northwest, about in the S. E. ¼ of sec. 31, Rose, on the north side of the Thessalon, near the road going to Otter Tail lake, the white quartzyte already mentioned again appears. The roadway passes over it The exposure is along the crest of a hill. The dip is S. 53° W. (mag.) 23° from the horizon. The rock rises but little above the general level, but the average level is over 100 feet above the Thessalon. The rock here is blotched with purple, and also has a green tint very common. The purple spots are due to dissemination of color from hematite nodules which are embraced in the mass of the rock.

Several ridges of quartzyte were seen between this place and Otter Tail lake, but by a winding route toward the east.

At Otter Tail lake, a mountain like ridge of quartzyte runs along the northeasterly side, dipping toward the lake, while at the southeast end a second one rises abruptly, and below it the former dips conformably at an angle of about 23°. The stratification is well shown on the abrupt end of this and was photographed, the view looking west.

At the village of Otter Tail, which is on the Thessalon river near its point of departure from Otter Tail lake, a little south from the post office, is a ridge of reddish weathering rock (1195) nearly on the line between Plummer and Plummer addition, which can appropriately bear the name felsyte. (Compare also rock 1182). It is roughly bedded, though plainly with every indication of sedimentation. It dips southerly to southwesterly, about 30 deg. and is banded with finer and coarser materials. The bedding varies in thickness from less than an inch to over twelve inches. But in general the rock of this ridge, which rises perhaps 200 feet above the village, and runs northwesterly, is very uniformly constituted. Its weathered surface shows different shades of red The bedding structure is not everywhere present. There are some large places where no bedded structure can be seen. Again, in one boss, or knob, of the general range, the strike is east, about 30° south; in another it is east, 30° north, with intermediate directions at intermediate points, or at points removed from both; another place shows dip S. 58° W. at an angle of 20°. The exterior surface is roughened by the removal of numerous small bits loosened by the diverse and frequent jointage. Some of the close jointed and most crumpled is coated, in the seams, with a green (chlorite?) substance, owing to more easy decay, and this also stains the rock itself to some extent, giving the appearance of some rock that has been called "trap." This rock which is here considered felsyte, has a compact uniform reddish-brown base or matrix, in which are scattered fine grains of free quartz. In other places nearly one-half of the whole seems, under the hand magnifier, to consist of quartz grains. Surfaces which show a brick-red weather-color, within are brownish-red.

Passing from this bluff across a small field in a southwesterly direction, and thus across the strike, we come to a nearly perpendicular bluff facing east, rising about twenty-five feet made up of rock similar to the last, evidently a part of the same. It here shows, in some of its parts, granular free quartz in abundance. It varies to a fine reddish quartzyte, and to a fine gray quartzyte. These varieties are shown by 1196, 1197 and 1198. No. 1196 is identical with the rock 1195. No. 1197 has a light pink-red weathered color but is brownish within. It is a fine granular felsitic quartzyte, and is separated into small angular blocks by frequent and intersecting joints. No 1198, which has a light yellowish-red, weathered surface is gray within, very hard, conchoidally fracturing, and is a sub-granulo-vitreous quartzyte, intermediate between 1172 and 1194. Although the dip is probably toward the southwest there is here a jointage system that resembles bedding that dips about 30°, from the horizon, N. 20° E. (mag.). Generally, however, at this point there is no remaining trace of the original sedimentary banding. The exposed area is about sixty feet square, and it seems to have a greater extension northwest where another hill rises seventy-five feet higher, though the surface intervening does not reveal the connection with the quartzyte.

This higher hill proves on examination to consist of a congeries of pebbles and boulders compacted with and modified by a rock similar to the red felsyte first described here (1195). It seems to have been a conglomerate with a matrix of the same material as the red rock. Indeed the hill is about in the line of strike from 1195, but not continuous with it—though the surface generally ascends from it, there being, however, a low spot between covered by drift. This conglomerate contains pebbles of red granulyte (quartz and orthoclase), but the great bulk consists of the rock 1199. It is a little darker colored, but otherwise this rock is identical with No. 1195, and probably in order of stratification, belongs below 1195.

[A few miles east from this place a large boulder of coarse conglomerate was seen by the roadside. It was red externally, and dark red within. It was evidently wholly fragmental, and had sedimentary bands of fine materials crossing it. But it also embraced red granulyte boulders, six inches across, as well as some of as great a size, of greenstones. It is to be supposed it was from the unmodified beds of which this outcrop is the upheaved, pressed, heated, and metamorphic condition.]

This observation near Otter Tail postoffice is a very important one. It shows the transition from felsyte to quartzyte, from 1195 to 1196, 97 and 98, all in the same formation. It seems to be conclusive as to the origin of felsyte, such as has been described in the Minnesota reports. It is similar to that seen in "the palisades" last year, [15th report p. 342] except that it is more quartzose in some of its parts, and is generally less crystalline, and much finer-grained.

As to the relation of this red-weathering, felsitic rock to the great siliceous quartzyte described at various points in the Thessalon valley below Otter Tail lake, there is little hesitation in placing it below it. The same kind of rock was seen, later, among the black slates of the region where it could only occupy a stratigraphic position in the slates, or of a modified portion of them. As mentioned below, the strike of this quartzitic felsyte, generally gray and less changed, extends several miles to the southeast from the ridge here described, constituting what is locally known as "lithographic stone," thus showing a long belt, with a nearly uniform dip toward the southwest. How far the ridge may continue toward the northwest is unknown. It is only by a line of fault, such as has been mentioned and mapped by Logan, running approximately coincident with the Thessalon valley and passing near this place, that this rock can be brought to this position, since the white quartzyte that skirts the east side of Otter Tail lake, dipping persistently toward the southwest would otherwise naturally run under this felsyte.

Toward the southeast, across a valley, from the hill containing the above rocks, (S. 70° E. from them) about half a mile distant, and also in the line of extension of the valley of Otter Tail lake, is another knob, but much lower, of rock like 1195. The dip here seems to be about vertical; but the banded structure is not well preserved, being changed rather to an incipient gneissic and interrupted foliation.

Toward the southeast still further, on higher land, areas of red rock can be seen showing weathered surface exposures evidently in the line of strike from 1195.

In close proximity to the last mentioned felsyte knob, but a little toward the northeast from the line of strike, is a hill of gabbro, represented by 1200. This comes within about ten rods of observed contact with the felsyte, the intervening space being covered by earth and soil. Toward the north this bluff breaks off nearly perpendicularly about seventy-five feet, down to the flood-plain of Thessalon river. Only the upper part is bare, but it extends unquestionably about forty rods southeast and northwest, and perhaps thirty rods northeast and southwest. It is a curious variation in the geology of the region, but is a further instance of parallelism between the original Huronian and the Animike rocks of northeastern Minnesota. This gabbro is on the land of Mr. Day.

About a third of a mile still further southeast, on land of Mr. Day, in the bottomland of the Thessalon, is an outcrop of what Mr. Day regards as "lithographic stone." This rises about twelve feet above the surrounding land, and is on the east side of the river. It runs from eight to ten rods in the direction of strike, and subsides below the soil. It dips S. 50° W. (mag.) and 27° from the horizon. It is 1201. It is highly siliceous and does not effervesce. Some of it is reddish and purplish, but by far the greater part is of a light drab color. It is very fine-grained and very hard. Some of it is well supplied with free quartz in minute grains visible under a magnifier, and some of the coarser parts are crossed by strings and bands of chert (1202). This rock is like some seen in the Animike, particularly some of the Gunflint beds. It is also the same as seen at "the dump," and is nearly in the line of strike from 1198 and 1195. It may be considered the same rock.

Rock 1203 (like 1200), an eruptive gabbro, forms a low ridge in the midst of higher hills of red quartzyte, in the N. E. ¼ of sec. 23, Plummer, a mile and a half from Otter Tail lake northeastward; appears in the N.—S. road.

At one mile south of Murray's Corners, S. E. cor. of sec. 2, Plummer, is another exposure of red felsyte, an area of it running northwest from near the north and south road, and rising high in the hill, represented by 1204. This is about five miles nearly north from the felsyte ridge described near Otter Tail P. O., and may be supposed to be the same stratum brought to the surface again on the north side of the great fault. Some of this takes a closely sub-crystalline form (1205); indeed much of it has this character. There is no constant dip, but in some places an indistinct banding is seen which shows an inclination about 50° from the horizon, N. 10° E. (mag.); but this must be only a local irregularity. Indeed the rock here is so much changed that all its original bedding is lost. Rocks 1207 and 1208 are also obtained from this ridge of felsyte, but they are sub-crystalline, and only red superficially, the rock 1208 being gray and apparently a fine-grained quartz dioryte. This recalls some such changes seen in the bluffs of the Animike in Minnesota, particularly that examined on the south shore of Loon lake.

This felsyte ridge has an interesting and instructive relation to another ridge of a different kind which runs northwestward, parallel to it, situated across a little valley about twelve rods to the southwest. This ridge, which is a characteristic bluff of characteristic Animike slates, dips 46° S. 30° W. (mag.), and rises above the little intervening valley from fifty to seventy-five feet. It runs nearly in the direction of strike of the rock of which it is composed. Its highest portion is toward the northwestward. There is nothing in this ridge but very fine-grained gray rock which is nearly black on fractured surfaces. It frequently has a rusted weather-scale about a quarter of an inch thick. It is minutely granular, almost aphanitic. It is thin-bedded but hardly slaty, evidently of sedimentary origin. On the weathered surface it is harsh, as if a fine net-work or frame of amorphous silica consituted the base of the whole. It breaks with a flinty sub-conchoidal surface of fracture. It is closely related to, if not identical with, the rock seen at the roadside (1194) and belongs to the same formation as the rock at "the dump" and the "lithographic stone" of Mr. Day, but probably its stratigraphic place is above the "lithographic stone." It here rises into extensive ranges of hills, and forms the rock of the country.

Murray's hill is at Murray's Corners, but a short distance east, and on the north of the road—S. W. ¼ sec. 36, Coffin. This hill rises about two hundred feet above the highway. It is rough and basaltified outwardly. The sedimentation dips 78° toward the S. 20° W. (mag.), thus throwing the beds far below those seen in 1206. If there be no irregularity the felsyte No. 1204 lies between them. Here the "black slate" is a granite-conglomerate, i. e. it contains numerous boulders of red granite. The boulders are almost wholly of red granite, and the rock is but scantily slaty in the direction of the sedimentation. Close jointage sometimes produces an appearance of slatiness. Neither has it any slaty cleavage. On the top of the hill some thin veins of white quartz stand above the surface. The general weathered aspect is slightly greenish, but the color within is dark-green to gray. This is mapped by Logan as the "upper slate conglomerate." The rock is shown by 1209. This rock appears like the Ogishke conglomerate of Minnesota. Its boulders, however, do not, here, embrace any of greenstone. At the foot of Murray's hill, on the west side, is a dike, represented by 1210.

At half a mile south from Murray's Corners, on land of Hugh Matheson, is a show of hematite in a reddish sort of quartzyte—1211. It runs in strings and thin veinings, mingled with quartz and some calcite. The quartzyte is fine-grained, and seems to form a large bed, perhaps fifty feet thick. It cannot all be seen. It is brecciated, and these minerals are in the cemented fractures. There was here an accumulation of iron in crystals, as well as of quartz. This rock is like some of the brecciated Animike of Minnesota. It is a very fine-grained quartzyte, slightly reddish.

At Riddlebank P. O., which is a mile and a quarter southwest from Otter Tail P. O. on the road to "the Bruce," is an exposure, or succession of low exposures, of slate conglomerate similar to that of Murray's hill (1212). This is rather fine-grained, greatly brecciated and cemented again with hematite (in black scales unless crushed), and shows frequent changes of dip, and frequent short faults. The pebbles are principally of red and gray granite, gneiss and allied rocks, but there are a few of red jasper. There are in it gray quartzyte beds ten to twenty inches thick, which weather much lighter colored from having feldspathic grains. This quartzyte is 1213. 1214 represents pebbles from this slate. Some are of gneissic crystalline rock; some look as if they were from older graywackes but contain feldspar porphyritically disseminated, and are schistose; some are of jasper, but the most are of reddish coarse granite.

In traveling from Riddlebank to Thessalon the road goes near Bruce mines (1 m. N. E. from "the Bruce"). At the point where the road comes nearest and turns easterly, a slate conglomerate like the last is found in some low exposures. It is probably what Logan styled and mapped "lower slate conglomerate," but it seems undistinguishable from the upper. It contains here large red-jasper pebbles.

Eastwardly from this place, along the road leading to Thessalon are seen low flat areas of the same conglomerate, dipping at a high angle toward the lake; and at one place a rock like that at Bruce Mines appears by the side of the road, distant about three and a half miles from "the Bruce." But it is evident that the eruptive rock which seems to be the prevailing one at the mines, containing the vein mined for copper, is not very extensive in geographic area toward the northeast, for this road runs within a mile, or less, of the lake shore, and passes through a fine tract of farming land.

At Blind River, which is a stopping place for steamboats, the river which gives name to the village has a double débouchure into lake Huron, the principal one being the more easterly and affording water-power for a saw-mill. There is abundant exposure here of the eruptive basic diabase or "dioryte" seen further west, though somewhat coarser grained than at Thessalon (1174). Here it has occasional specks of red feldspar disseminated. It is dark-colored, rough, though glaciated, spreading generally in low knobs that rise from ten to twenty feet above the lake. On the east side of the mill are quartzytes dipping S. 10° E. (mag.) about 48° from the horizon. One bed of quartzyte, part of which is certainly in the form of a chemical vein, is about ten feet wide. It is followed on the south by dioryte, about forty feet, when quartzyte returns, varying from dark to pale red, but mainly gray, and continues to the lake shore—about fifty-five feet. On the north of the first mentioned bed of quartzyte the dioryte extends indefinitely. This quartzyte seems indistinguishable from some of that seen at Thessalon; but in general it is finer-grained and more vitrified, approaching, in a degree, the texture and color of the so-called "chalcedonic silica" of the iron-bearing rocks at Vermilion lake in northern Minnesota. The line of contact between the quartzyte bed here described, and the greenstone on either side is not straight, nor parallel with the strike of the quartzyte, but off-sets right and left, like a fracture-plane rather than a plane of sedimentary superposition or of igneous overflow; but in the main it coincides with the strike of the quartzyte.

A little further north, at the recent cuts made by the Canadian Pacific railway, the relations of these two rocks are evident. There is a continuous rock exposure from the lake to the railroad, and the cut shows the relations expressed by the subjoined diagram—figure 4, which is a view of the north side.

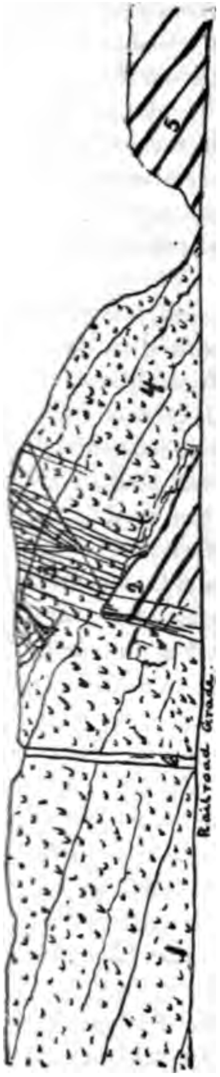

Fig. 4.—*Railroad cut showing greenstone lying on gray quartzyte. Blind River.*

Explanation of Figure 4.

2. Dioryte, showing coarse flowage-bedding often seen in overflow sheets of eruptive rock, and particularly in the great gabbro sheet of Minnesota.

2. Quartzyte, pinkish, with detached masses on the right indicating the direction of flow of the molten rock. These detached masses are pink when large, but some of them are greenish, at least superficially, with chlorite, but gray within. There is some difficulty in distinguishing them all from the enclosing igneous rock, since they come to look like the fine-grained contact parts of it.

3. Basaltic columns developed in the upper part of the igneous rock from the cooling in contact with quartzyte.

4. Dioryte not basaltic.

5. Quartzyte.

6. Quartz vein.

This ridge of quartzyte rises toward the southwest so as to coalesce with a general quartzyte area. The superficial area of the dioryte running to a point between them.

The quartzyte has patches of chloritic shaly quartzyte, some of it with less fine quartz. This is visible on the face of the perpendicular cut. The southwestward dip is exhibited plainly, but the contact of the two rocks, when sketched, is a straight plane, perpendicular to the horizon, visible specially on the south side of the cut, and continuous to the north side, where it is perpendicular or slopes a little to the northwest. Fortunately the conjunction of the railroad grade with this contact is so near the top of the ground that there is visible a continuous mass of the dioryte, spread over the surface of the quartzyte and extending again below the level of the grade and continuing till the quartzyte rises and spreads out eastwardly without interruption. There could be no more conclusive demonstration of the eruptive and later origin of the greenstone. Rocks 1175–1179 illustrate the foregoing description.

The same fine-grained gray quartzyte, varying to pinkish and dipping toward the lake at an angle of 80° from the horizon, is seen to constitute the long point that projects from the mainland southeastwardly from the westside of the westerly delta-arm of the river. It strikes W. 10° S. (mag.). It is in thin beds, and though the grain and color is much like that already described at Blind river, it is strikingly unlike that seen at Thessalon. Indeed its physical character seems to ally it with the slate formation and the rock immediately overlying the felsyte at Otter Tail P. O. rather than with the great conglomero-quartzyte described at Thessalon. Compare rocks 1197 and 1198. The point is crossed by a diabase dike (1181) forty-eight feet wide, which runs about in the direction of the strike; and by another about parallel near the lake shore a little further south.

Missasaugui river. Toward Missasaugui river, from Blind river, along the new grade of the Canadian Pacific R. R., the first outcrop is about a mile and a quarter from Blind river. It consists of glaciated domes of diabase, rising on the south side of the grade. But a short distance further west, on the same side of the grade, can be seen other similar domes, but on the north side of one of them is a lenticular area of pinkish quartzyte, the greatest length being about east and west in the direction of the strike. Toward the east it is enveloped entirely by diabase, and toward the west it is hid partly by diabase and partly runs under the soil. The northern contact plane is nearly perpendicular.

The next visible rock is at the west delta-arm of Blind river, where the new railroad crosses it. It is quartzyte, but has some dioryte associated with it. The dip is confused, but at one place it was seen to be distinctly toward the N. N. W., the reverse of that along the lake shore. But this is likely to be only a local irregularity.

At about three quarters of a mile east of the Missasaugui river is a low cut in the quartzyte, and some of it is light greenish, or pea-green, shown by 1183.

At the railroad cut at the Missasaugui, east side of the river, the igneous rock is exposed. It shows a rude flowage-structure dipping N. W., and it embraces red felsitic portions, of irregular shape and position. These are very conspicuous, and very interesting because they illustrate again the same manner of origin of felsyte as has been mentioned. These pieces (1182) can be accounted for by supposing them to have been loosened fragments from the country quartzyte enclosed in the molten rock at the time of the eruption, and in that way fused and welded to the diabase. These isolated red felsyte pieces have considerable free quartz, but it cannot easily be ascertained whether the grains have a crystalline form. The bulk of it is aphanitic, opaque and reddish, and the silica seems to have been feebly disseminated in the felsitic groundmass, chemically losing its identity in whole or in part.

Different conditions and stages of this interesting combination are here visible. One is that of the quartzyte, in association ,with the diabase becoming affected by heat, some of it becoming infused with what now appears like a green chloritic matter, the quartz losing some of its distinctness—1184. Another is of the same character, but darker—1185. Still further, and the change developes an orthoclastic tendency—1186. Again, without being colored by the interpenetration of any of the basic elements, the changed quartzyte becomes dense and fibrously basaltified, appearing, structurally, like the basaltic red felsyte of the "great palisades" on the north shore of lake Superior—1187. The last step in the mingling of the two rocks is seen in the formation of an orthoclase dioryte, or orthoclase gabbro, wherein the silica of the quartzyte, fused in the mass of igneous matter, apparently having sought as an acid the strongest alkaline base (potash), has combined so as to make a dioritic rock that is speckled with red orthoclase crystals—1188 and 1189. These stages are all visible within a small space at the railroad cut at the east side of the Missasaugui. When opportunity occurs a special study and presentation of these varieties of rock and their paragenesis, in connection with other similar facts that have accumulated during the past ten years, going to show the origin of felsyte from sedimentary rock, and not from a deep eruptive source, will be made in some of the publications of the survey.

At the mouth of the Missasaugui, on the west side, a dome of dioryte rises from the water's edge having the character of 1190, and on its southerly margin has an abrupt contact on a fine-grained, gray, almost flinty quartzyte which dips south at an angle of about 80° (1191). This dioryte has a different aspect and apparently a different composition from any rock seen in the area of the original Huronian. Its association is somewhat different also. The fine-grained quartzyte with which it forms an abrupt contact, while probably a part of the quartzyte series seen at Blind river, which also extends along the shore between Blind river and the mouth of the Missasaugui is darker colored, and much finer than the great Thessalon quartzyte and evidently occupies a lower stratigraphic place in the Huronian. Its granular structure is compacted, and cemented closely by secondary silica. Its coloring material gives it a suggestive alliance with the dioryte, and, owing to the greater metamorphism to which it has been subjected leads to the possibility that the adjoining dioryte is itself only a modified condition of some part of the great slate formation, the transition being similar to such as have been noted in the Animike in northern Minnesota at various places.

On the east side of the Missasaugui, at its mouth, is a beautiful expanse of this quartzyte, making the outer breakwater of the lake shore and enclosing a little bay where the river enters. The strike is persistent here and conspicuous, W. 5° N. (mag.), and the dip about 75°, toward the lake. False bedding and slaty characters coincident with the stratification, are features that appear in some of the layers. No. 1192 represents one of the greenish weathering, more slaty parts of this quartzyte. This quartzyte is cut by a greenstone dyke running S. 66° W. (mag.), showing non-conformable relations with the strike, and hence non-inter-bedding. This dike is about forty feet wide.

Between Missasaugui and Blind rivers an inspection of the shore in a row-boat revealed nothing except the quartzyte 1191, with an occasional dike or overflow-area of some greenstone eruptive. The dip of the quartzyte is regularly from 75° to 80° into the lake, and the immediate coast-line is for nine-tenths of the distance composed of it. The greenstone dikes have a direction about W. 20°—30° S. (mag.). They are represented by rock 1181, from the point off the mouth of Blind river.

CONCLUSIONS RESPECTING THE ORIGINAL HURONIAN.

This examination of the original Huronian, of which the foregoing is a brief account, leads to some important results which have a direct bearing on the classification of the rocks of Minnesota, and of the northwest.

In general, the stratigraphic grouping of the parts above noted, is about as indicated by Logan in the report and atlas of 1863, except that the "green chloritic slates," so-called, are not at all included in the terrane as constituent parts of the stratigraphy. They are a part of the eruptive basic rocks of the region, and very doubtfully ever become slaty—indeed they never exhibit the slatiness of roofing slates, and only rarely have that interrupted, wavy, thin bedding which appears on the weathering of a once molten mass indicative of an internal fluidal structure. Their macroscopic mineral characters also ally them closely with the greenstones. These slaty characters moreover are found only in the midst of areas of undoubted eruptive greenstone. Not only is this "chloritic slate," but all the "greenstones" are excluded from the Huronian. They are regarded by Logan as accidental features, except so far as they are named, and colored as "green chloritic slates." In his map, and in his table of stratigraphic parts of the Huronian (map of 1865), there is absolutely no other reference to the vast outflows of greenstone that cover many square miles in the Thessalon valley, and that constitute hill-ranges as conspicuous as those of any rock in the region.* The limestones also are quite subordinate parts, belonging in the slate number of the Huronian. They are siliceous and cherty in some cases, and very fine-grained. A limestone which is more like a gray crystalline marble appears a little northwest of the old Wellington mines, belonging in the "lower slate conglomerate," of Logan, but time was not afforded to examine into its stratigraphic relations.

It thus appears that the original Huronian can be divided into three grand divisions, viz.:

1. Red and white quartzyte, granular and sometimes conglomeritic.
2. Slates and gray quartzyte, sometimes conglomeritic.
3. Very fine-grained white or gray quartzyte.

No. 1 overlies No. 2. No. 1 includes the parts 3l, 3i, 3h, 3g, of Logan's tabular statement accompanying his map of the region, of 1865. No. 2 includes 3f, 3e, 3d, of the same table. No. 3 includes 3a and probably 3c. No observation was made that fixed without doubt the positions of his parts 3k and 3c, but from what was seen it is inferred as probable that his 3k belongs in No. 2 and his 3c in No. 3.

It seems necessary to recognize the *fault* which Logan represents running on his map northwestwardly up the Thessalon valley, by which the lower rocks are suddenly brought to the surface and made to appear, according to the prevailing dip, to lie over the upper.

No. 1, above, is divisible into at least two subordinate parts, but it is not supposed that the character on which these are based—that of color—will be found sufficiently constant to warrant the extension of this division beyond the limits of the original Huronian area, though other distinctions may be discovered which will permanently characterize these members over a broader area. 1.—Otter Tail quartzyte. 2.—Thessalon quartzyte. The highest member of the Huronian is the Otter Tail quartzyte. It is nearly white, but in limited areas it is both conglomeritic and pinkish. It also is greenish sometimes. Its greatest and characteristic exposure is in the hills along the east side of Otter Tail lake, and at the southeastern extremity of that lake. Its thickness is several thousand feet, but there was not time to ascertain it carefully. The underlying quartzyte is red or reddish, occasionally conglomeritic, and perhaps prevailingly somewhat finer-grained than the last. It is that member which would most probably afford catlinite, and perhaps the fossils of the catlinite in Minnesota, if similar clay beds could be discovered in it. The chief outcrop of this quartzyte which was examined occurs in the Thessalon valley forming a ridge running nearly east and west and rising to the hight of 150 feet above the adjoining low land on the south. This ridge is on the north side of the Thessalon and its composition is represented by rock 1171. The thickness of the strata here is also several thousand feet, but no exact measurement was attempted.

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*His map is also incorrect in other respects. It represents the Laurentian as occupying the lake shore for some miles at the mouth of the Missasaugui and the Blind rivers, where the only rocks are quartzyte and greenstone.

The subordinate parts of the other principal members are as follows: 3 —Black slate, identical in all characters with the slaty beds of the Animike in northeastern Minnesota; siliceous, carbonaecous, slaty in the direction of and incident to the sedimentation. This is supposed to embrace the limestone layer which appears near "the Bruce." This sometimes varies to a somewhat harsher grayish feldspathic quartzyte. It appears about two miles south from Murray's corners, north from Otter Tail lake, and there constitutes a series of ridges and hills that give the country a very rough contour. It contains, in some of its more quartzose strata, considerable quantities of hard black micaceous hematite distributed, along with amethystine quartz, in veins which have recemented the fragments after the strata have been brecciated. 4.—"Lithographic stone." This is found in the bottom-land of the Thessalon river a short distance below Otter Tail lake, on the south side of the great fault. It strikes from there northwestwardly and appears, in a somewhat more granular and siliceous phase, on the south side of the red felsyte hill near Otter Tail P. O. This is only a modification of the slates of No 3, by the increase of calcareous sediment, and the greater fineness of the siliceous. 5 —Red felsyte. This is found forming a ridge that rises about 200 feet, near the village of Otter Tail. It appears again, on the north side of the fault, about two miles south of Murray's corners, and again at "the dump," where it is represented in figure 4. It is roughly stratified, and is plainly only a modification of some of the beds of the formation. It is probably not a continuous layer. 6.—The Missasaugui quartzyte. This differs from the great quartzyte forming the summit of the Huronian in being always gray or white, very fine-grained, and dense. It seems to fade gradually into the more siliceous portions of the slates and to become, in some places, interbedded with slates. Its thickness is probably not less than 1000 feet. 7.—Slate conglomerate, seen at Murray's hill, near Murray's corners. This is one of the principal members of the Huronian. It is repeated in Minnesota in the Ogishke conglomerate.* Its thickness is probably at least 5,000 feet.

These are the principal masses, and they exhibit the principal aspects of the sedimentary rocks of the original Huronian. The order in which they are named above, while agreeing mainly with that given by Logan, cannot be considered established certainly by the observations we were able to make. One of the most important points to be noticed in this is the evidence of two great quartzytes, having many common features, but separated by a great body of slate and perhaps slate conglomerate.

These rocks are not crystalline, but fragmental, and show, except where they have been modified locally by contact with eruptive rock, every character that is known to indicate sedimentary origin. There are no mica schists, no sericitic schists, no hornblendic schists, no typical graywackes, though the dark slates sometimes become coarser-grained and approach the well-known wackenitic ensemble, no gneiss or gneissic rock except what is very limited in amount and is directly referable to contact with greenstone.

Among the greenstones it is not designed here to include the dioryte seen at the mouth of the Missasaugui. There are reasons which it is not necessary to mention at this place, that induce the writer to entertain a strong doubt as to the eruptive nature not only of this dioryte but of all the quartz-diorytes that are associated with these slates and quartzytes in northeastern Minnesota.† All the facts that have been observed by the Minnesota survey conspire to show they are derived from metomorphism of some of the sedimentary rocks of the group, although the preponderance of opinion of microscopic lithologists is to consider them of original eruptive origin.

The Minnesota parallels of these rocks have been indicated already in giving the local descriptions, but a brief repetition will not be out of place. It may be included in the following tabular statement:

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*See the 15th Annual Report.

†Compare the description of the quartz-dioryte at Little Falls, on the Mississippi, by Streng and Kloos; 11th annual report, pp. 34 and 74.

Original Huronian.	*Minnesota equivalents.*
Otter Tail quartzyte. Thessalon quartzyte.	Pewabic quartzyte (?) New Ulm, Pokegama and Wauswaugoning quartzytes.
Black slate.	Animike black slate.
"Lithographic stone" and fine gray quartzyte.	Not known.
Red felsyte.	Felsytes at Duluth and probably the Great Palisades.
Missasaugui quartzyte.	Not known.
Slate conglomerate.	Ogishke conglomerate.

There is some reason to infer that there is an unconformity between the Thessalon quartzyte and the Black slate. This evidence consists in the existence of cherty and quartzyte pebbles in the quartzyte which seem to have been derived from the Black slate strata. The same kind of evidence, the existence of granite boulders in the slate conglomerate, indicates another unconformity between it and the granites of the region that lie to the east and northeast of the Thessalon river; but in the latter case the evidence is conclusive, and in the former it is but inconsiderable.

THE IRON-BEARING ROCKS AT MARQUETTE, MICHIGAN.

*At Negaunee.** Some observations were made at the new mines situated about two miles east of Negaunee. There is a singular irregularity in the rocks of the region seen in this vicinity. The Iron Cliffs and the Sam Mitchell mines are troubled by a sudden inthrust of the north wall, by which the body of iron ore is entirely cut off at an angle which, in the latter mine differs from horizontality but fifteen degrees, sloping downward toward the south. The strata carrying the ore dip northward from 65° to 80°, and this inthrust, therefore, which consists of a great quartzyte of unknown thickness, cuts the strata off nearly at a right angle. In the Iron Cliffs mine the superintendent followed the upper surface of this quartzyte, which here descends much more rapidly than in the Sam Mitchell, downward in a shaft to the depth of about seventy feet, following a two-foot layer of soft greenstone, hoping to get below the troublesome quartzyte, and then by drifting southward to find the ore again. But at about seventy feet he was intercepted by another quartzyte which seemed to be one of the beds of the iron-bearing rock, which, dipping northward at the same angle as the ore, abuts upon the intruding quartzyte so as to leave but a space about two feet wide between them. This space was occupied by the soft greenstone he was shafting in, and, though it changed its direction so as to become perpendicular he followed downward between the quartzytes to one hundred and fifteen feet without change, and was there at work at the time of this visit. The next mine toward the west is the Buffalo, in which no such trouble has been experienced, the formation dipping regularly toward the north, or north northwest, at a high angle.

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*In passing from the area of the original Huronian to Marquette opportunity was afforded to note the dip of the sandstone causing the rapids at the outlet of lake Superior. It was found to be about 10° from the horizon, 10° south of west, magnetic.

This troublesome quartyzte is represented by Nos. 1141, and 1253, the latter however from the south side of the shaft at the depth of about 115 feet. They are identically the same gray quartzyte, rather finer grained than the great overlying quartzyte of the original Huronian, and more or less mingled with a green matrix, a siliceous graywacke. The circumstances appear to indicate a synclinal folding of the gray quartzyte, the mines from which the ore has become temporarily exhausted, being in the basin of the syncline where it is shallow and runs near the surface. At the depth of 115 feet it appears that the folding was so sharp that the quartzyte was brought against itself, or was broken and thrust against itself at a higher level. This is indicated not only by the identity of the rock on the north and south sides of the shaft at 115 feet, but by the continuation of the two-foot bed of greenstone which runs down between the quartzyte beds, up to the top of the mine on the south wall of the open pit in conformity with the iron ore beds and with the main quartzyte bed on the south side.*

A similar quartzyte, but more like a siliceous graywacke (rock 1248) sometimes having a greenish aspect, appears on the northern part of the Buffalo property, (next west of the Sam Mitchell) at the railroad-cut, in such a position as to suggest the probable continuity of the rock from the Sam Mitchell mine. It here apparently dips N. and is overlain by a black slate (1249) which graduates downward into a contorted greenish slate (1250) which lies directly on the slickensided upper surface of the quartzyte. These all dip north, but this quartzyte seems to have an unconformable upper surface. It is rounded and undulating, as well as slickensided. These slates lie directly upon the quartzyte (or graywacke) at the railroad cut, but toward the westward they seem to separate, the quartzyte becoming lost, and in its place on the south side of the slates there being an old dike which runs conformably with the slates westwardly across the railroad and on to

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*A similar abrupt cutting off of the ore in a mine by an inthrusting quartzyte is described by Brooks at Michigamme, the inthrust also coming from the north. *Geol. Surv of Mich. vol i. p.* 123.

the next knoll where these slates become somewhat iron-bearing (1252), and the selvage of the slates, the hardened and broken wall, alongside the old dike, projects above the ground conspicuously. Here the dike is hardly visible, but can be occasionally seen on the south side. This old dike is a very different rock from the slates, microscopically (1251). It is coarser but even grained, has a light green color, no free quartz, is sub-talcose to the touch, is lenticularly schistose perpendicularly, without sedimentary banding, cut by frequent quartz veins. It is probably the same greenstone which runs across the Iron Cliffs mine, and in which the superintendent shafted between the quartzyte masses.

At the Iron Cliffs (1143) and the Swan mines (which latter is a short distance west of the Buffalo) the ore is interchangeable with quartzyte, both across and in direction of the strike, large portions being rejected from the strata which, about 20 feet right or left, in the direction of the strike, were wholly reserved and shipped as ore. This irregularity is distinctly observable at the Swan mines. The sedimentary rock graduates from 1247 A, a coarse fragmental stone, mainly quartz but with glittering facets apparently of minute crystals of magnetite, through 1247 B, an impure hematite banded with light red, chalcedonic silica, to 1247 C, an earthy hematitic jasperoid rock, banded and clouded. This shows a common origin for them all rather than a chemical or eruptive source for the jaspilyte and not for the others.

Occasionally also, at the Iron Cliffs mine, the red hematite is associated with lumps of siderite, some of them being six or eight inches in diameter. There is a gradual transition from one to the other, through a yellowish limonite (1142).

Along the north side of Teal lake at Negaunee runs a range of hills made up of a nearly white granular sometimes pebbly quartzyte (1252). It is blotched with red, ripple-marked, evidently fragmental, and dips south, 18° W. about 65°. This is mapped by major T. B. Brooks as continuous with that which forms the "capping" of the ore at Ishpeming. Here it dips as it does there, *apparently* below the ore. It embraces not only pebbles of quartz but some of other kinds, among which may be mentioned a light greenish, very fine-grained serpentinous rock, and a soft red hematite. This is an immense quartzyte, visibly 200 or 300 feet thick. On the north side of the bluff it graduates downward into a thin-bedded, feldspathic fine-grained gray quartzyte (1234)* exactly duplicating the section seen north of Ishpeming.

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* This seems to be the rock worked for honestones; *Rominger; Geol. Sur. of Mich. vol. iv.*, *p.* 41.

Whether this is here a conformable transition is not quite certain, as there is but a slight outcrop of the thin-bedded gray quartzyte at the point examined. Next along north of this quartzyte range is a range of dioryte hills. This quartzyte is, in the opinion of the writer, the equivalent of the *Otter Tail quartzyte* of the original Huronian, and lies unconformably on the iron-bearing rocks at Negaunee.* This will be made more apparent on giving the observations made at other points.

An old, much altered, dike can be seen cutting this quartzyte near the east end of Teal lake (1255). It is somewhat serpentinous and schisto-fibrous, of a prevailingly grayish-green color but striped and blotched by different amounts of iron-oxide. This gives it, in some places, a pseudo-aspect.of sedimentary banding.

At the Eldridge mine on the south side of Teal lake, which is as yet only an exploration, the shaft penetrates one hundred and fifty-three feet perpendicularly a red "soap rock," which is said to dip south as if it passed beneath dioryte hill near which it is located.

At the Hartford mine, a little further west, still on the south side of Teal lake, the situation is similar to that at the Eldridge, and a good, massive hard bluish ore is taken out.

Next west in the Cambria mine the formation also dips south. This mine has been long worked, and has sent out a large amount of ore. The mining operations exhausted a large basin-shaped pocket of ore, shut in by "jasper" on all sides, and on the bottom; the working could not be extended. Drills were run in all directions into the "jasper" and through it, but nothing more could be found of the ore. They are now exploring by following a narrow bed of ore northwestwardly, shafting and drifting.

The outbreak of the dioryte hills between Negaunee and Teal lake seems to have had no effect on the dip of the formation, since it dips southwardly on both sides of these hills.

At Cascade, which is four and a half miles south of Negaunee, the iron-bearing rock dips toward the north at all the working mines. An interesting feature here is the evident fragmental character of the ore rock. It is not only in beds that vary in thickness from less than half an inch to three or four feet, with a conformable dip 28°—40° N., but some of them contain rather coarse grains of clear quartz, about as large as mustard seeds, which are disseminated in a manner characteristic of sedimentation through some of the layers. In other places the ore consists almost entirely of fine magnetic octahedrons (1217). Some of the micaceous, massive hematite contains great numbers of small cinnamon colored garnets.

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* Compare *The American Geologist*, March 1888. *A great primordial quartzyte*. N. H. Winchell.

Lying unconformably on the edges of the ore-rock is a quartzose conglomerate, (1218 and 1219). At the bottom, this conglomerate is dark, ferruginous and pebbly, the pebbles being from the fibrous hematite of the region, jasper and white vitreous quartz, some of the latter also being purplish or smoky. *It also contains pebbles of the very fine-grained quartzyte or "chalcedonic quartz" peculiar to the iron-bearing series at Marquette and Vermilion*, and of other sorts of rock. Toward the upper part this conglomerate becomes simply a quartzyte, white or dirty white, and is seen covering several acres, and extends at least half a mile from north to south. On the summit of the hill just south of the old workings of the Watson mining company (Bagley hill) the appearance of this conglomerate is represented by the figure attached. (Figure 5.)

Here but 12 feet can be seen, dipping apparently N. N. E. about 15 deg., but it continues in knobs and hills of higher and higher strata, toward the north and northeast, showing a thickness of several hundred feet. At the recent new mines of the Pittsburg and Lake Superior Mining Company, about half a mile toward the northeast, two shafts pass through this rock, one 250 feet and one 175 feet, and nothing else, except some soft shaly material (6 to 10 feet), where they struck the iron ore formation. This conglomeritic quartzyte appears above the surface in numerous places, one knob being on the "Location" (at Palmer P. O.) It here dips 35° toward the N. 40° W., or toward the new shafts. It here contains numerous pebbles ½ in. to 1 in. in diameter.

From the fact that pebbles of red jasper, chalcedonic silica and red hematite occur in this conglomerate it is apparent that the iron ore formation *must have been constituted in pretty nearly its present state prior to the formation of the conglomerate.* This quartzyte-conglomerate appears to be no other than the southern rim of the synclinal of which the quartzyte on the north side of Teal lake is the northern rim. While dipping in the same direction, in general terms, the two formations do not dip conformably. If the detailed structure could be known it is probable, further, that faults would be seen producing sudden upthrusts of the underlying formation, causing the apparent overlie of the lower on the upper, as at Thessalon.

Ishpeming. The basin or synclinal trough seen at Negaunee extends westward to Ishpeming; and the same general features are seen there.

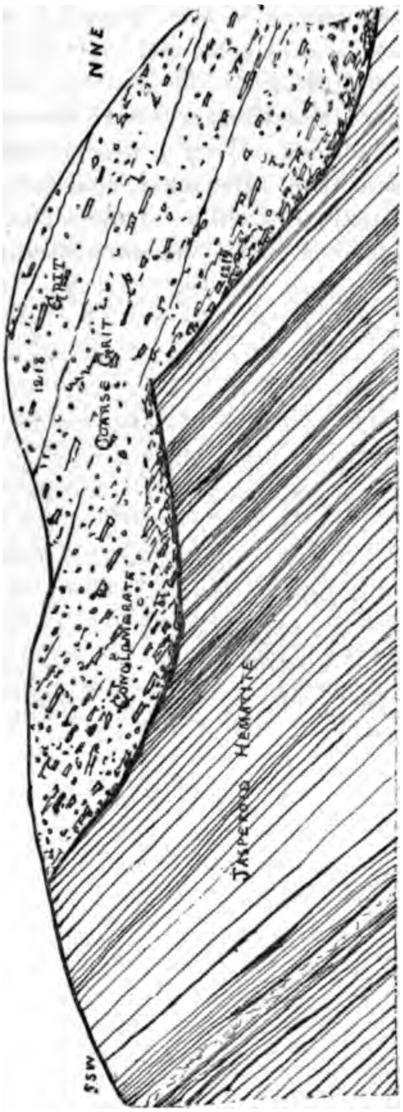

Fig. 5.—*Unconformable conglomerate* [Potsdam] *lying on the iron ore at Cascade, Michigan.*

There is an unconformable overlying quartzyte which on the north side is seen dipping south toward Ishpeming, and on the south side consists of a conglomerate in every respect like that at Cascade, the iron formation dipping toward the north. Intermediate between these rims lies the city of Ishpeming, and the mines (some of them) penetrate first a great thickness of the quartzyte and then come at once upon the ore. This overlying quartzyte appears in the streets of the city and is well known as the "capping" rock of the ore. It has been bored through at a great many places, and its greatest thickness, so far as discovered, is near the center of the basin, amounting to 300 or 400 feet. It is thinner toward the north and toward the south, and finally runs out entirely in those directions, the width of the trough being here about three miles, or about half as much as at Negaunee. The synclinal structure of the valley is well known, and the quartzyte is supposed by all the mine operators, and by all

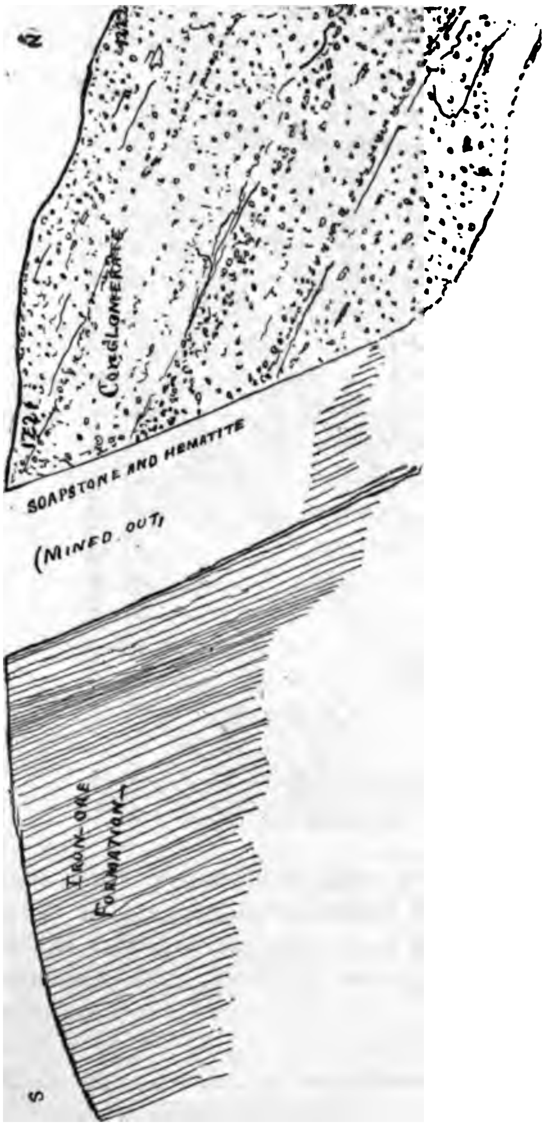

Fig. 6. The unconformable conglomerate at the Old Saginaw mine. Near Ishpeming, Mich.

geologists so far as I have learned, to be conformable with the rock carrying the ore.

The old Saginaw mine, S.W. from Ishpeming about three miles, is a repetition in all respects of the Bagley Hill works at Cascade, and the unconformable position of the conglomerate-quartzyte on the ore can be seen with even greater distinctness than at Cascade,—(rocks 1221 and 1222). Fig. 6 was sketched here. It illustrates the situation at one of the easterly small openings in this property. Further north the quartzyte rises considerably higher in rounded glaciated hills. On the northerly side of one of these knobs, in lower ground, a drill hole was made 400 feet into this quartzyte, in a sloping direction toward the south, without piercing it. *

The bed of overlying quartzyte appears again about a mile north of Ishpeming, where it causes by its outcropping edge a series of low hills that run east and west and dip toward the south. On the south side of Deer lake, where this quartzyte is cut by the grade of the railroad, it is reddish to purplish, and dips south at an angle of 50 degrees. It can here be traced almost into contact with a massive-to-schistose greenstone on which it would lie unconformably. The quartzyte here is represented by 1228, and the greenstone, which is sometimes basaltic, by 1229 and 1230. This is all on the west side of the creek just below the outlet of Deer lake. On the east side, on either side of the road to Ishpeming, the relations of these rocks are further exemplified. This massive-to-schistose greenstone becomes conglomeritic and rises abruptly in a hill at the immediate roadside, on the north of the road, to the hight of about a hundred feet, while just on the opposite side of the road appear some slightly lower layers of the quartzyte dipping at about the same angle as on the west side of the creek. These lower layers are thinner, somewhat slaty, glistening with hydro-mica scales, finer grained than the bulk of the quartzyte, and comparable to the thin layers of similar rock seen below the quartzyte on the north side of Teal lake. (1234). They dip below a quartzyte knob like 1228, conformable with it.

This hill of conglomeritic greenstone, which is situated just south from Deer lake, was carefully inspected, owing to its likeness to the schistose conglomerate seen in the Vermilion region in Minnesota. It is illustrated by rocks 1225 and 1226, and in all respects is identical with the conglomerate seen on Stuntz island in Vermilion lake, as

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* Major Brooks represents this conglomerate here, and at other places, as interbedded with the iron formation; and Dr. Rominger regards it as conformable with the ore formation. Wadsworth, however, has alluded to the legitimate conclusion to be drawn from this unconformability. (Notes on the geology of the copper and iron districts of Lake Superior, p. 31).

described in the fifteenth annual report of the survey. It is soft, quartzless, or nearly so, light green, becoming darker within, especially when less changed by age and exposure, spotted (but sparingly here) with forms of boulders that are of the same stuff as the rock itself, fibro-schistose nearly vertically, cut by quartz veins, and in some places porphyritic with some feldspar. No bedding structure, such as can be attributed to sedimentation, can be seen in the rock, but along the south base, near the road, a thin-bedded, even slaty structure, standing vertical can be seen, which may be the original sedimentary bedding of the formation through which this as an eruptive may have issued. This also is a light greenish rock (1227), and were it not that it shows a markedly different structure which seems to be attributable to an original sedimentary origin it could easily be classed with the rock of the main hill and considered a part of it. But there is not a similarly abrupt change in the general mineral characters of the rocks concerned. There is what might be considered a sericitic element pervading both, giving them a slippery or "talcose" feel, and some of the schist is essentially a serpentinous schist, and fragments from it seem to be included in the agglomerate. Some of the bands that simulate sedimentary structure are finely porphyritic, and resemble the mass of the rock of the hill. The whole situation here is such as to show a non-conformity with the quartzyte across the street—whatever be the relations of the schist to the rest of the hill. This hill is a part of that which has by Dr Rominger been classed in his "dioritic group." It seems closely connected with the "serpentine group," and indeed the writer without much hesitation regards the two as one group, the serpentinous condition prevailing whenever, locally, greater alteration has taken place in the original rock, which was an eruptive, basic one. It overflowed, and mingled with the rocks of the iron-bearing series unconformably, and where it is now in contact with them it constitutes at least in some places the "soapstone" and the "chloritic rock" of the mines. Subsequently the rocks of the Huronian were deposited unconformably on the iron-bearing and serpentine groups, these consisting of the quartzyte, the novaculitic and the black slates. These were disturbed by later eruptions and cut by other dikes.

Westward from Deer lake, traveling toward the Ropes gold mine, this pebbly greenstone continues, and appears in numerous outcrops, and in the vicinity of that mine the rocks are nearly all serpentinous. This is five miles N.W. from Ishpeming. The quartz vein (1233A) which is mined for gold is in an old, much changed eruptive, (1233) of a greenish color, hardly schistose, a part of the same formation, at least a part of the same formation as the pebbly greenstone already described (1225, 1229 and 1230). The quartz was chemically deposited. It is vitreous and white, not "chalcedonic." In the immediate vicinity of the mine the rock affords chemically deposited limestone (1231) which has been used for flux in the furnaces of the region. This limestone is associated with a considerable magnesian element, since in the cavities and veins are found nodules of pure talc (1232.) It is crystalline and of a gray color.

Recently a valuable deposit of gold has been discovered on the land of the Lake Superior Iron Mining Company about two miles southwest from the Ropes mine. This is in the same kind of silica, and very probably in the same country rock.

At the Michigamme mine, the working is in a magnetic quartz schist, the ore being represented by 1238. This graduates into jasper and hematite, the whole dipping S. and apparently lying on a dioryte which rises in a prominent range running E. from the mine. At a little further east this horizon of ore is a ferruginous laminated quartzyte, still dipping south, away from the dioryte; still further east, and a little further north, it dips in the opposite direction, indeed dips in nearly all directions, some of it being nearly horizontal, appearing as a dark micaceous and garnetiferous (?) quartzyte upheaved by the underlying dioryte which rises in isolated hills in different places. Still further north, about half way toward the granite range, are several such isolated crags of dark quartzyte, most of them dipping about 66° toward the south—1245 and 1246. This quartzyte is cut by dikes of this dioryte.

At the granite range, which lies about a mile north of Michigamme, a gray, somewhat gneissic quartzyte, comes directly in contact with the granite. This granite (1240) is red, and very siliceous. The ridge rises about 150 feet, and at the southern base a gray, coarse, fragmental quartzyte forms a crooked contact with it. It is not easy to see which overlies. A lot of conglomeritic pebbles of white quartz are stuck on the south face, which dips at an angle of about 80° south. But these may not have been conformably stratified with the quartzyte, but due to the quartzyte having abutted on the granite. At the contact there is abundance of quartz disseminated through the granite as shown by the specimen 1240 which was got 3 feet from the contact on the north side. The visible contact line is about vertical, but dips 80° north, as if the quartzyte ran under the granite. There is also some feldspathic material disseminated from the contact southward through the first six inches of the quartzyte. Compare 1241, 1242, 1243 and 1244. The quartzyte takes a gneissic structure near the contact.

At another place, a little further east, the contact is such that it appears to show that the quartzyte lies on the granite. Time was not sufficient to make further examination as to which rock here is the older.

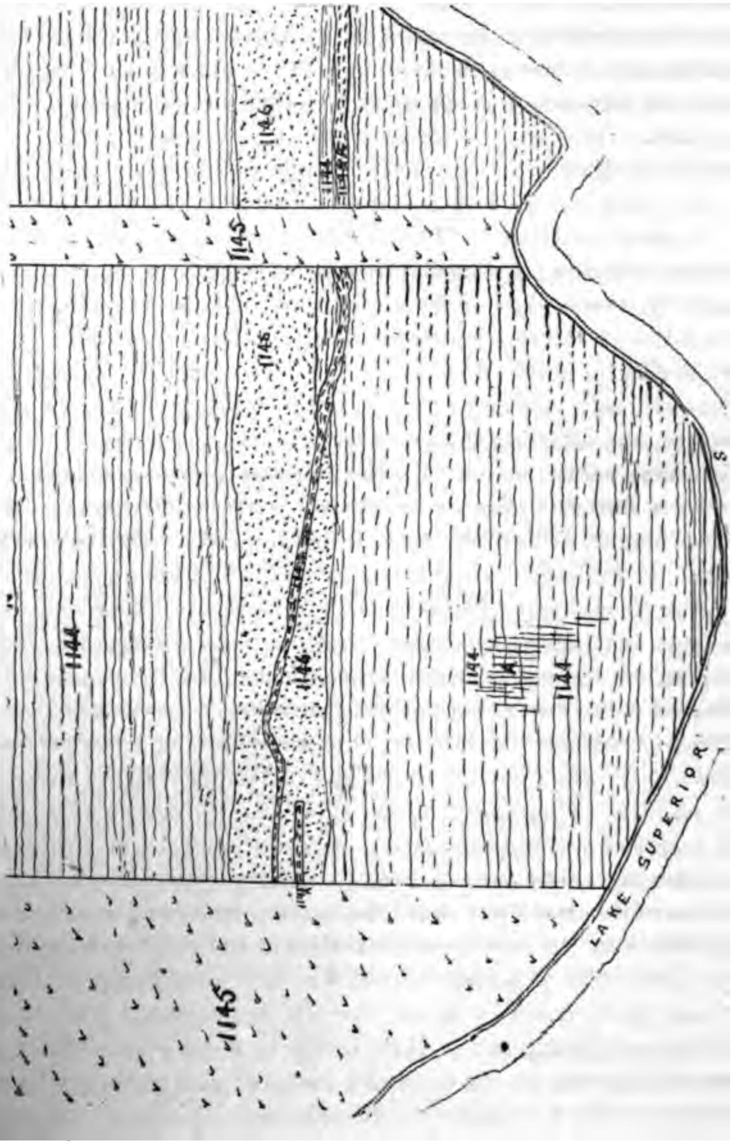
At Marquette. Passing along Bluff street northward toward Lighthouse point, one occasionally sees outcrops of a greenish schist standing up nearly vertical and apparently forming the foundation rock of the drift-covered bluff that rises on the left. Near the extremity of the bluff, not far from the lake shore, at the saw mill, this schist appears slightly in the road (1147), and although a part of the general formation of the country at Marquette it has some exceptional features which ally it with the serpentinous rocks at Presqu'Isle and at Deer lake. These features are believed to be due to a more advanced stage of decay. It is a silky, hydromicaceous or talcose, rock, without apparent bedding but fibro-schistose about east and west. It appears, under the hand glass as if the fine grain, of which it entirely consists, might be fine "chalcedonic" silica, but on being scratched it is seen to be too soft, giving easily a white streak. The rock is slaty-schistose but not slaty, and has a pinkish tint outwardly. It is translucent, in thin scales, and is veined with chemical quartz. It passes in a short interval by insensible gradations through 1147A, which is the same as 1147 but with some felspathic aggregations, as if porphyritic, somewhat greenish, to 1147B, which is apparently a much altered, old eruptive fine agglomerate, recalling the rocks seen westward from Deer lake to the Ropes mine, a part of the serpentine group of Rominger and the equivalent of the Stuntz island agglomerate of the Vermilion region. A little further east is an outcrop of a rough-looking eruptive rock with twining coarse flowage structure, that extends to the water's edge.

Northward from this, along the lake shore and extending to the extremity of Lighthouse point, is a greenish, nondescript rock. On first view, owing to a banding and lining that somewhat resembles that of sedimentary structure, this rock might be considered as a fragmental one, and so the writer was disposed to regard it, at first, but on taking a more extended view of the general geology and also a more careful inspection of the rock itself, he is inclined to consider it, and all the rocks on Lighthouse point, as probably of eruptive origin, and a part of the "dioritic group" of Rominger, which apparently cannot be separated genetically nor geographically from the serpentine group. There are, unquestionably, diorytes, and eruptive diabasic rocks of later date than these rocks, and some of them may occur within the same areas, but these old "diorytes" that are marked by so much decay and that probably underlie the black slates and certainly underlie the great quartzytes unconformably, constituting a part of the "iron-formation" proper, are considered by the writer to belong to an older epoch of wide.spread eruption, one that seems to have preceded immediately the epoch of the Huronian. The same succession of great rock-masses seems to have taken place in northeastern Minnesota and has been alluded to in the 15th annual report of the survey, p. 381.

The strike of these schistose rocks on Lighthouse point is 10° W. of N. (mag.), and the structure stands at an angle of 80° from the horizon, dipping northerly. The whole point on which the lighthouse stands, enclosing the harbor on the south side is made up of, and caused by, a congeries of fractured parts of this greenish schist with later dikes of doleryte and belts of quartz porphyry. This later doleryte constitutes nearly one-half of the hill where the lighthouse stands, but it swells out and recedes very irregularly, forming unexpected bosses, and allowing the schist to take its place again.

This greenish schist, which in some places is very firm (1144) and only shows a fibrous grain on weathered surfaces, is heavy, dark within, free almost, or entirely, from original quartz. On its weathered surface its structure is indicated by bands of varying shades of green, and in its seams it glitters with hydro-mica. These bands of color are not continuous, but consist rather of an interrupted, narrow, striping in which the color lines become lost by running to needle-shaped points, or by fading into each other. The single, light-colored lines sometimes continue for only a few feet, or a few inches; and in some cases when narrow they rise and disappear in the space of less than an inch, bringing the darker lines into contact so as to present the aspect of a nearly homogeneous green rock. At the same time in some places they are not direct, but have, when fine, a fluidal waving toward the north or toward the south. In other places again, and particularly on the northwest extremity of the point, the striping which resembles that of sedimentation is more evident and persistent, and in some parts could be more correctly denominated a banding, some of the bands being two or three inches in width—but even then they lose their identity in ten or twelve feet, and give place to a finer, schisto-fibrous lining. The feldspathic element is gray, and evide some plagioclase.

The reddish rock, or quartz-porphyry, No. 1146, is not comn Besides a conspicuous dike of it on the shore southeast from the li house (whether dike or not) there is a patch of it near the wate the extremity of the point; and on the north side of the point nearly conformable narrow bed. This last runs thirty-five feet



is visible all the way and at both ends. It runs out to sharp points and vanishes in the green rock in the same way that the granite, of thin beds, does in the gneiss and mica-schist at the northwest end of Vermilion lake. There is, however, here no gradual interchange of minerals between the two rocks, or successional gradation toward each other, but the porphyry appears abruptly, as an individual rock, quite different from the rock of the point, and maintains its mineral character even into the narrow points at each extremity. This bed is about a foot wide near the middle and reddish, but at the points it is more like a gray quartzose layer, (1146A). It is about 35 feet long, and appears conformable except that it swells out and again dwindles. This, however, is seen in all the beds of the schistose greenstone; see figure 7.

Explanation of Figure 7.

This sketch represents the relations of the different dikes to the rock of the country, on the south side of Lighthouse point, a little to the west of the lighthouse.

1144 is the schistose rock of the country, having a structure running nearly east and west. At the place marked A is an indistinct north and south banding or striation on the surface of the schist, due to the existence of some siliceous veinings that do not wear away as easily as the rest of the rock. This transverse fine veining is represented by 1144 A. It has no important significance other than that there has been exerted on the formation a force that produced an incipient fracturing and a fibrous internal arrangement nearly at right angles to that which is seen generally in the prevailing rock. At various places in 1144, especially south of the lighthouse, there appear to be minor unconformities within the rock. The fiber, running in one direction, is cut off by a compacter rock, though not distinguishable otherwise from the rest of 1144, that has its fiber perhaps finer than the other and running in a slightly different direction. Sometimes whole bands, an inch or two wide, are thus crowded out by the encroachment of others. These little irregularities are no greater than are seen sometimes in eruptive rocks, such as that figured on Stuntz island in Vermilion lake, in the report of last year, nor are they very different from that which is known as false bedding in sedimentary rock. The non-conformity of the rock 1146 (quartz porphyry) with the rock 1144 is about of this kind, though in other places it is non-conformable with 1144 more abruptly, even existing as blocks embraced in it. On the north side of the point the schist (1144) while more conspicuously banded east and west, and more persistent in all its structure, is strikingly basaltic by joints running north and south, causing a columnar aspect, resembling that seen in the eruptive rock at Taylor's Falls on the St. Croix.

1146 is a reddish-gray quartz porphyry, already mentioned. It evidently is a part of the same formation as the schists, and if not of the same origin it has very nearly the same age since it is cut by all the later dikes. North of the lighthouse this rock has its greatest development. In addition to the narrow dike already mentioned is another which intersects the point east and west, cutting off a portion which is separated from the main part of the point by a gorge caused by its more rapid disintegration. This more rapid disintegration is not because of the softer grain of this porphyry, but is caused by the close jointage which cuts it into blocks that are separated by frost and roll down to the lake. This dike is best examined NW. from the lighthouse near the water heel. The dike of 1146 shown in the sketch is cut longitudinally by a straggling dike of another sort (1145A). On the north side of the point, near where the vanishing dike of quartz porphyry occurs, is a dark dike (1145B) probably of the same age as 1145A, about a foot wide, mainly conformable but vanishing in the same way in indeterminate points. (1145A) gradually works southward, in passing through 1146, and at the east leaves it entirely and enters 1144.

1145 is the latest of the eruptives of the point. It cuts all the others and its contact is a plane running N. and S. It forms a large part of the most elevated portion of the point, and spreads irregularly and apparently occupies several fissures that run across each other.

By examining the dikes of different rock cutting this point the succession of steps that gave them origin seems to be as follows:

1. The schist is the oldest rock. (1144).
2. The quartz porphyry was introduced. (1146).
3. The dikes 1145A (and perhaps 1145B) were introduced.
4. The great north and south dikes were formed (1145). There is confusion in the direction and areas of these latest dikes. There seems to have been a tumultuous breaking of the rocks, and an outpouring of the molten matter wherever fractures occurred and allowed its escape.

THE GOGEBIC IRON REGION.

A cursory examination was made of some of the mines in the Gogebic iron region in order to be able to compare the features of the rocks and the manner of occurrence of the ore with the iron-bearing rocks of the Vermilion iron range, and some rock-samples were collected for future microscopic comparisons.

The Colby Mine. At the Colby mine the average dip is about 60° toward the north, 10° west. There is apparent no hanging wall or foot wall except the rock of the country, and that is a thin-bedded siliceous rock which itself is almost ore in some places, because of the high degree of ferruginization. This siliceous material is jasperoidal and distinctly bedded exactly like the bedding of sedimentation. The base of it all is apparently a fine "chalcedonic" silica, the same as that of the jaspilyte, though in some, or many, of the beds it is a softer material which may be earthy. When the latter is stained they call it "paint rock." But it is not the "paint rock" or "soapstone" that is derivable from the eruptives as at the Cleveland mine. Samples No. 1256 represent three of the forms of rock that alternate with each other forming the country rock that constitutes the north wall in the Colby mine. The south wall of the south Colby mine consists of a crumbling, coarsely granular. siliceous sandstone (1257), the grains being sub-angular after disintegration. In some places it is firm and correctly bears the name of quartzyte. It is stained, locally, with much or little iron, and with manganese. The "silicification" process seems here certainly to have produced fragmental silica, and subsequently, being interrupted, to have been followed by the process of ferruginization, which stained this sandstone with iron and manganese, sometimes almost constituting it an iron ore. It is not possible to say this ferruginization is a secondary, or rather a third, step, later than the general ferruginizing process, and that this quartzyte has acquired the iron by reason of the accidental contiguity since, for the quartzyte graduates into the rock of the mine, the acquired substances (iron and manganese) being the same as in the real ore. The general circumstances of the situation will not allow of such a separation.

About 250 feet further north is an opening known as the North Colby. This is a long deep pit, where the iron has been worked out superficially, and timbered shafts are being prepared for deeper mining.

On the spur-track from the Colby to the Valley mine is a short cut in siliceous, greenish and yellowish slate, now largely ferruginous. This is sometimes earthy, like some seen at the Colby mine, but it is very siliceous with "chalcedonic" silica, some of it being almost wholly white, although the prevalence of hydro-mica, and perhaps of other fine-grained mineral particles intimately disseminated through the siliceous parts gives a greenish color to even the hardest and most quartzose parts of this rock. This dips so as to conform to the rock in the Colby mine, and probably lies under the foot-wall of the South Colby. The full thickness of the bedding here involved, making allowance for the oblique direction in which the road goes across it, is about 250 feet. See rock 1258.

At the Valley mine the working is all under ground. Numerous test pits, and two shafts have been sunk, striking rock and ore similar in all respects to the rock and ore of the Colby mine, except as yet nothing is to be seen of the coarse sandstone which lies as the foot-wall of the South Colby.

In a ditch by the side of the railroad track at Bessemer is a small exposure of the bottom-conglomerate of the Cupriferous. It contains numerous pebbles of quartz and of fine porphyry like the coppe bearing conglomerate at the Calumet and Hecla mine. The dip ca not be made out as the exposure is small, and the pebbles rath evenly distributed throughout the whole. This conglomerate mu lie in unconformity on the Gogebic iron-bearing rocks, and if it the equivalent of the conglomerate at Negaunee (Cascade) as it a pears to be (see p. —), it indicates the greater age of the Huroni quartzyte (the N. Y. Potsdam sandstone) than the Cupriferous form tion—*i. e.*, than the greater part of the Cupriferous, since the Cupr erous strikes east and west near Bessemer, forming a conspicuo range of hills of eruptive rock but about a mile further north, t dip being such as to cause it to overlie this conglomerate.

The Aurora mine, at Ironwood, has a sandstone, or a soft quartzyt rather coarse, identical with that on the south wall of the Sou Colby mine, for its south or foot-wall.

At the Aurora mine an interesting observation was made on t "granite" which forms a low hill-range a short distance south of t mine, and its manner of contact with the rocks lying just north.

The low granite range, which has been mapped as Laurentian l the Wisconsin geologists, rises about fifty feet above the mine, a lies south from the mine about six hundred feet. The section strata intervening between the mine and the granite range is ma up about as follows, in southward (and descending) order:

1. Iron ore, soft hematite. 100—150 feet.
2. Sandstone (sometimes a quartzyte), about 15 feet seen.
3. Gray and greenish slates and quartzytes, in beds from half an inch to fc and six inches; distinctly sedimentary, 580 feet.
4. Gray quartzyte like that of No. 3.
5. Granite; hornblendic and massive.

The sandstone (No. 1) forms the south wall of the Aurora min The quartzytes and slates (No. 2) are not all exposed at the mine, b at the Colby mine a section of 250 feet, in a connected exposure, c be seen along the spur-track west of the mine. About 100 feet similar strata are visible at the Aurora mine. Samples 1261. It partly assumed, therefore, that the whole interval of 580 feet consi of the same rock as seen at the northern and southern limits. seems to be a part of the Animike slates and quartzytes.

The granite (No. 5) is a hornblende-granite. Sample 1260. rises in rounded bosses and forms three separate low bluffs or hi ranges, each about 15 feet higher than the next one further nort The rock itself contains boulder-forms of different rock from the ma of the granite, some of them being of some dark-colored greenstone-like rock, and others of some earlier granitic rock. The great mass of the granite is mainly homogenous, and these boulder-forms appear most distinctly on the weathered surface of the bluff. When these boulder-masses were not originally of greenstone they are apparent by a blotched aspect which the granite presents, the blotches being caused by some patches, of rounded outline, much finer grained than the rest, or by a marked difference in the relative amounts of feldspar and quartz compared to the same minerals in the most of the granite. The boulder-forms are, when distinguishable, from two or three inches in diameter to twelve inches. Their longer axes lie prevailingly in the same direction, but sometimes they have lost their first shape and have been drawn out into points in one or more directions, or have been a little distorted by unequal pressure. *

This granite also has a uniform rift, or grain, brought out by the constant, or prevalent elongation of the hornblende crystals in the direction about E. & W. The boulders have their longer axes in the same position. It appears, therefore, that originally this granite was some conglomerate, which has been plastic or fluid-like.

At the most southerly of the three low bluffs of this granite, each of which faces toward the north, the granite can be seen, on the north side, to lie upon, or at least alongside of a gray quartzyte. (1261). There is an abrupt and simple contact line, and a sudden transition between them.

About 25 feet further north is the second low northward facing bluff of granite. It here looks as if the granite had been a molten rock and had flowed unconformably over the quartzyte, the dip of which cannot here be ascertained.

The third low outcrop of the granite is about ten feet lower than the last, and about 30 feet further north. In the north face of this little bluff, not more than six feet high, is observable the contact seen in "Fig. 2" of fig. 8. Here the granite is unconformable on, and embraces pieces and tongues and slabs of the gray quartzyte and quartzyte slates (1262). This quartzyte-slate is fine-grained, banded by sedimentation, and light-greenish weathering. It is greenish-gray within. Sample 1262. At one point in this little bluff is a small area of granite surrounded by crumpled and broken portions of the slate. So at least it appears on the face of the bluff, but this

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*Similar changes from conglomerates to gneiss are mentioned by Dr. E. Hitchcock in Vermont, in *Am. Jour. Sci*, (2), xxxi, 372.

isolated granite area is only superficial and doubtless was, and perhaps is still, united with the main granite mass.

These three little bluffs, running, so far as they have apparent extension, in the same direction, do not conform in their trend with the direction of strike of the bedded rocks that intervene between them and the Aurora mine. They vary from it about 20 degrees, as illustrated in "Fig. 1" of fig. 8.

The interpretation of these facts, and their bearing on the strategraphic problems that relate to the horizon of the iron ore of the Gogebic range seem to warrant the following conclusions:

1st. The granite acts the role of an eruptive rock, but was originally a conglomerate. It was so far molten or plastic that it flowed over the adjoining sedimentary strata, but not so completely fused as to have rendered the resultant granite entirely homogeneous.

2nd. The accompanying beds of sedimentary rock being a perfect lithologic representative of the quartzytes and slates of the lower part

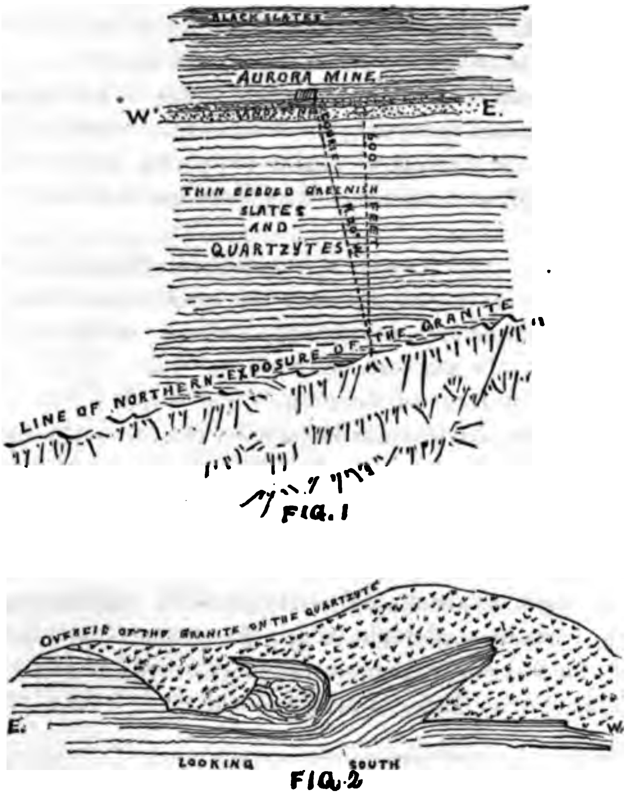
BLACK SLATES
AURORA MINE
W.
E.
THIN BEDDED GREENISH SLATES AND QUARTZYTES
LINE OF NORTHERN EXPOSURE OF THE GRANITE
FIG. 1
OVERFLOW OF THE GRANITE ON THE QUARTZYTE
E.
W.
LOOKING SOUTH
FIG. 2

Fig. 8. *Plat and section at the Aurora mine.*

of the Animike. this conglomerate can be parallelized, stratigraphically, with the Ogishke conglomerate of Minnesota in which have been seen (Fifteenth annual report, and later in this report), similar semi-fused conditions, producing porphyries, syenite and porphyritic conglomerates.

3rd. The horizon of the ore of the Gogebic range is probably that of the Animike rocks.

4th. The granite is not of Laurentian age, but is younger in its present condition than the Animike slates, though originally a conglomerate older than those slates.

Explanation of Fig. 8.

The upper portion (Fig. 1) shows the ground plan of the rocks south from the Aurora mine.

The lower portion (Fig. 2) shows the overlie of the granite on the quartzyte—looking south, upon a low bluff facing north.

At the Iron King mine the following information was obtained of foreman Lehman. Five shafts have been sunk, two on the south "vein," and three on the north. Those in the south ore-bed are said to furnish ore that "has too much manganese;" but those on the north deposit furnish a superior soft hematite. The ore, after the shaft penetrated the "cap rock,"[*] widened out to eighty feet, and runs east and west. The rock intervening between the ore-beds is not exactly known, but the walls of the north deposit are, quartz on the south and "paint rock" on the north and extending north from the ore forty or fifty feet, where it becomes black slates. Between the two ore-beds is quartzyte, jasper and sandrock, mixed, judging from surface outcrops, the distance between the north and south ore deposits being about four hundred feet. The jasper is "not good red jasper, but gray to black-like, or flinty." The ore in the south bed is 80 to 100 feet wide, and "no regular hanging has been struck;" but no great development has been done there because there seemed to be some trouble with the ore. It is not known what the foot or hanging may be on the south bed of ore.

About a mile east of the Iron King mine a deep drill was being made in the "black slate" which overlies all the mines, and runs apparently in an east and west belt next north of the line of the ore deposits. This slate is shown by samples 1263.

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[*] The imported term "cap rock," probably comes from the miners of the coal measures, and it has no definite application nor significance in the mining of iron such as found in the lake Superior region. It is used as a convenient designation for any rock that overlies, or obscures, the chief ore deposit. through which a shaft passes before reaching the ore.

At the First National mine the same general geological facts seem to exist. There are what are known as the south "vein," and the north "vein." These are simply conformable beds in the general system or series of strata which for some reason are now highly changed and charged with hematite, or hematite and manganese, and sometimes (especially further west) with magnetite, in variable proportions. There is the intervening series of strata that, while not ore, yet are so charged with iron that some portions consist of lean ore, known as jasper, quartz, sandrock, slate rock, etc. There is the quartzyte foot wall on the south side of the south ore-bed, and the soap-rock and black-slate on the north from the north ore-bed.

Visits and short examinations were made at several other Gogebic mines, especially such as are open pits without much underground mining, such as the Montreal, Kakagon, Bourne, and the Atlantic, but nothing was seen that would throw further light on the general geology or the relations of the ore to the crystalline rocks of the northwest. A trip to the *Penokee gap* was made by Prof. A. Winchell, and his report thereon will be found in another chapter.

FROM GRAND MARAIS TO GUNFLINT LAKE.

From Grand Marais to the crossing of the Devil's Track river, sec. 32, 62-1 E, not a single exposure of the underlying rock is to be seen along the usual trail running to Rove lake. The country is timbered with deciduous trees mainly, but with some scattering cedar, balsam and white pine. The whole intervening belt is fit for farming and will ultimately be occupied by farmers. The drift sheet is not superficially stony so as to impede plowing. At about a fourth of a mile north of the Little Devil's Track river was a patch of potatoes and corn. Large timothy grass grows along the roadway (Aug. 26, 1887) and is cut and stacked for hay.

At about a mile north of the crossing of the Devil's Track the red-rock of the country is crossed by a narrow belt of trap about half a mile wide, rising about 15 feet above the rest of the country and trending W. N. W. and stopping on the north side in the form of a perpendicular face. On the north of this the country is drift-covered again, but has a superabundance of red-rock boulders, verging to red granite, and an occasional one of sandstone.

The descent to Clearwater creek, on the N.E. ¼ of sec. 20, 62-1 E, is about 130 feet, and a marked topographic feature is the hill, or ridge, known as "Birch ridge," which here presents a bold face toward the north of about that hight. This ridge seems to run across sec. 20, and along the south side of Clearwater lake, which is the lake crossed by the line between secs. 19 and 20. The Clearwater creek, running from Clearwater lake, is a small affair, but has very cold water, meandering through a cedar swamp.[*] Elbow creek is larger. They both run over a rather smooth drift surface, about ten feet below the average level. A low trap exposure is seen about in the N.E. ¼ of sec. 9, 62-1 E, and boulders of trap and gabbro are seen in the N.E. part of sec. 17. This outcrop is rather fine-grained and somewhat porphyritic, but resembles much seen on the lake Superior shore. When weathered it assumes a brownish-green color. There is but a slight exposure, the surface being in general drift-covered, and merely undulating, with timber mostly fire-killed. About an eighth of a mile south of the town line, in the N.W. ¼ of sec. 3, 62-1 E, we crossed a little southeastwardly running creek. This is near the south foot of what is here known as Pine mountain, so named because it was formerly covered with pine. It now presents a bald, rocky outline, with only the charred remnants of the original forest.

At the place of our camp (Aug. 27) just south of the creek, a low ridge of fine-grained gabbro (or a greenstone) 1264, runs parallel with the direction of the creek forming its southern barrier, but this ridge is not continuous. It rises and falls, wholly disappearing towards the N.W. It is evidently one of the minor ranges of hills that attend mountain elevations generally, and consists of the same rock as Pine mountain.

Pine mountain is evidently only a local name for a part of an important hill-range. This range can be seen toward the west two or three miles distant, and presents the outline of eruptive dike-formed buttes in some of its individual hills. It seems to be the same that I met with on this town line not far east of here in 1879[†] and is in general known as the *Brule mountains.*

South from this trap ridge (mentioned) the country is red in some places with the debris of red-rock drift and chips, exactly like the red shingle on the Grand Marais beach, making it probable that, with small exceptions where the basic eruptive rock breaks through, this red rock underlies the drift to this place. But there is so much drift that the actual areal distribution of these two rocks cannot be ascertained with any degree of minuteness.

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[*] The outlet of Clearwater lake is represented on the township plats as being toward the south into Devil's Track lake, but Dominick says there is no such tributary to that lake, and that its outlet is eastward and then southeastward.

[†] The present Rove lake road is new, only made about two years ago, and while it coincides in some places with the old road, at this place they are nearly a mile separate.

On the top, where the trail goes over this range, no rock is visible. Much drift covers it, but the trees are fire-killed. South, 25° W., can be seen a square-topped mountain which Dominick says is Cascade mountain, near the mouth of Cascade river.

After passing the main hill, from which lake Superior can be seen, but where there is no rock in outcrop, a lower, bare hill can be seen a little to the north of the main range, conical in shape (S. E. ¼, sec. 33, 63-1 E.) and having the color of the rocks of the Misquah hills (1265). Several similar hills occur near, but they are mainly drift-covered.

The Brulé mountains which seem to be largely composed of this red rock, are well named.

Such hills of red rock continue a distance northward, and the whole country is composed of such rock, which is easily disintegrated by the fires and the elements so as to cover the surface with thin gravelly soil, as far north as the southern part of sec. 4, 63-1 E. About six miles distant, in the direction toward Greenwood lake, but to the S. W. from that lake, a bare, red peak of greater hight can be seen. Beyond Greenwood lake, and rising much higher, is a long E. and W. hill covered with green timber, which Dominick calls *Greenwood mountain.* It seems to be a part of a general range of similar hills, and is probably a portion of the true (gabbro) Mesabi.

The Brulé river occupies a very deep and broad valley, running in the red rock along here, at least through T. 63-1 E. The rock itself is not frequently exposed, but the soil, and debris resulting from its disintegration, and frequent boulders, or fragments, are composed of it.

There is a marked difference in the manner of weathering of this red rock, and the ordinary gabbro. The latter never turns red, but crumbles down, maintaining its earthen gray color. Large boulders of it, seen along here, decay through and through, and pass into soil, through a pebbly condition. Where they lie on the red rock, thus crumbled, they present an appearance of little loads of gravel dumped—wheelbarrow loads, or wagon loads, according to the size of the original boulder. But the red rock, in all boulders, and all debris, is red, brick-red; and *in situ* it is superficially brick-red, and brownish-red within to any depth so far as ever observed. This brownish-red color is probably due primarily to the presence of a large amount of orthoclastic feldspar, and it prevails through all its degrees of fineness, from felsyte to red granite. When this rock is coarser crystalline it sometimes acquires a tendency toward a gray color, due to the presence of more free quartz, some hornblende, and apparently of some plagioclase, the red orthoclase crystals being disseminated more or less sparsely through it. It then seems to grade into a rock which has been designated sometimes a dioryte. Such a variation in color was noticed just before reaching the crossing of the S. Brulé.

There is a low, narrow ridge of gabbro-like rock, crossed by the trail in sec. 4, 63-1 E; but north of that the red-rock returns and and continues to the centre of sec. 19, 64-1 E. It is, however, covered with a coarse drift of large boulders consisting of gabbro, porphyry, red-rock and amygdaloidal trap; and in secs. 30 and 29, 64-1 E, this kind of drift is heaped up in morainic tumuli. These accumulations run in diverse directions, the larger number of the boulders being of the red rock. At the crossing of the N. Brulé, and south from there, are many porphyry masses, and many amygdaloidal boulders. These porphyries are sometimes stellar, in the manner of arrangement of the crystal tables, with a dark matrix; but sometimes a mass appears which is crowded with tabular crystals (1265A) from one to three inches in length, and not more than an eighth or a quarter of an inch in thickness, also with a dark (basic ?) matrix. Some masses are both porphyritic and amygdaloidal. In studying these boulders, in making the passage along the trail, one can note easily an increasing tendency toward dioritic characters—that is an increase in non-red-weathering feldspar, greater size of the individual crystals, dark hornblendic crystals mingled with schillerized surfaces, and occasionally noteworthy quantities of scattered magnetite or menaccanite.

There is north of the North Brulé much "orthoclase gabbro" among these boulders, that is a dark, coarsely crystalline rock with some red-weathering element, the conspicuous minerals being, besides the red feldspar, a white feldspar, magnetite (or menaccanite), long crystals of hornblende and some quartz. The red element here sometimes is not crystalline, but is in disseminated blotches of amorphous felsitic matter. This felsitic matter, which seems to act the part of the undifferentiated residuum of the molten mass, is disseminated through the otherwise dark gray or dark green rock. One large boulder in particular lies in N.E. ¼ of sec. 19, 64-1 E, and from this was taken samples No. 1266. This boulder is specked with red feldspar, but has also some plagioclase that does not take a red color, but rather becomes snowy white on weathering. Blotches of red felsitic matter are scattered over its outer surface, some of them being six and even ten inches in diameter, and through these blotches run strings and coarser crystals of hornblende. It also contains some quartz and magnetite. Within, this boulder does not maintain its red color, but appears like a heavy, dark (dioryte ?). In the immediate vicinity are a great many boulders of the same kind, making it probable that their native place is not far away. They are curiously and coarsely specked on the weathered exterior. The red spots are non-crystalline, apparently, but are cut and crossed indiscriminately by all the crystals. The largest and most abundant are of some white-weathering feldspar, next the hornblende, then magnetite, then quartz.

But a short distance beyond (north) where these specked boulders lie, the same rock is seen in place. It occurs as an irregular dike or blotch elongated about east and west, and on the north it has the red rock in contact. 1268.

Rock 1267 represents a frequent form of amygdaloidal porphyry seen south of the North Brulé in the form of boulders.

The red rock, north of the contact above, is variously modified by different degrees of crystallization, but extends about 20 feet north and gives place to a belt of greenstone, which itself is again replaced by 1266, though the last here shows much more white-weathering feldspar, and less of the red uncrystalline matter. Rock 1266 continues about ten rods, but at the summit of the ridge, near the north side of sec. 19, 64-1E, the underlying rock is more fine-grained, though essentially the same as 1266. It is represented by 1269.

It seems possible to trace here a gradual transition from the red-rock to the eruptive rock 1269, and to 1266.

These latter are apparently forms of the dioryte that lies on the animike hills further east, and which is interbedded with the slates and quartzytes of that formation.

As we approach Crocodile lake (which is in the southern half of sec. 8, 64-1E.) on the portage from Round lake, a small outcrop of Animike rock appears near the lake, but a little further east large areas of (gabbro?) form the shore and rise in bluffs from the water.

On the portage from Bear Skin lake to Cariboo lake (N. ½ of sec 5, 64-1E.) in a small boulder of Ogishke conglomerate, which is rather far east for drift-transport from any point at which this conglomerate is known *in situ.*

The high hill just to the east and on the south side of the narrows of Rove lake, situated north from the center of sec. 28, 65-1E. was named ***Mt. Reunion,*** from the fact that here (i. e. at the Narrows) my party met again, according to appointment, that of my brother, after having been separated about a month.

North from the north side of North lake, nearly in a line due north from the north end of the portage from South lake to North lake, begins a trail that leads to Northern Light lake. At a little less than a mile from North lake, on this trail, a very light-colored micaceous gneiss is found, forming low hills. The weathered surface shows that there is a large ingredient of feldspar, but on a fractured surface the grains are nearly all glassy, as if it consisted of nearly all quartz. This pseudo-siliceous appearance is due to the glassy nature of the white feldspar. All the grains are fine. (1270.)

Between the lake shore and this gneiss is one outcrop of dark trap rock; and numerous fragments of the red and flinty beds of the Gunflint series indicate the rocks that intervene between the trap and the gneiss *in situ* in the intervening belt, but of the latter no actual outcrop was seen on this hasty excursion.

No. 1271 is oolitic bloodstone, or red-brown jasper, one of the forms of the Gunflint beds. This is heavy with hematite. It also was brecciated, and now holds angular fragments of rock like itself. It is also finely crystalline, appearing like No. 866A seen on the "south ridge" at Tower, where the jaspilyte appeared to have been fused and then to have taken on a sub-crystalline structure from a fragment found on the surface.

The rapids going out from North lake are caused by beds of Animike and basaltic hardened Animike 1272. The strike of the latter, looking like trap, is visible about 20 rods east of the rapids under the water of the lake, but rising nearly to the surface.

No. 1273, dense blackened trap, just west of the rapids last mentioned, north side. A short distance further west appears No. 1274, a firm mica-gneiss, similar to No. 1270. The trap must lie upon the gneiss (1274), which is in outcrop a short distance further west.

ABOUT GUNFLINT LAKE.

On the north shore of Gunflint lake, about a mile west of the entrance of the river, this trap (gabbro?) lies on a series of slates and flinty beds, the upper part of the series being changed apparently by the gabbro. No. 1275 is from the upper part of the gabbro here seen. It is made up, macroscopically, of a gray plagioclase, and a dark mineral, probably augite. These two seem to constitute the bulk of the rock, and it is with difficulty and much uncertainty that any other mineral, except a rare grain of magnetite, can be distinguished under the hand-glass. It is thus quite different from the rock

1266 and 1269. The underlying sedimentary beds are slaty and flinty, interstratified. Some of the strata, near the overlying trap-sheet, are plainly modified by the heat of the superincumbent mass. No. 1276 represents such a modified form of the Gunflint beds, and 1277 shows the flinty character of some of these beds. The former is from between beds of black thin sheets of horizontal slate, some of the latter adhering on each side of the specimen. It is composed essentially of pieces and granules of a dark gray, aphanitic rock varying in size from that of a pin-head to peas, or larger, closely compacted together, but cemented in the interstices by a glassy mineral that appears to be free quartz, the general aspect being that of a dark, basic, dense diabase specked with minute white spots.

About half a mile further west, on the north shore, where the bluff ceases, and a bay extends toward the north, the trap lies directly on the slates, with little flint, and with little modification of the slaty beds—Fig. 9. The trap, however, is rendered black and very fine-grained at the bottom and for some space upward—say six feet—but graduates into rock the same as 1275 at the top, making a basaltic capping over the slates, *similar to that at the east end* of South Fowl

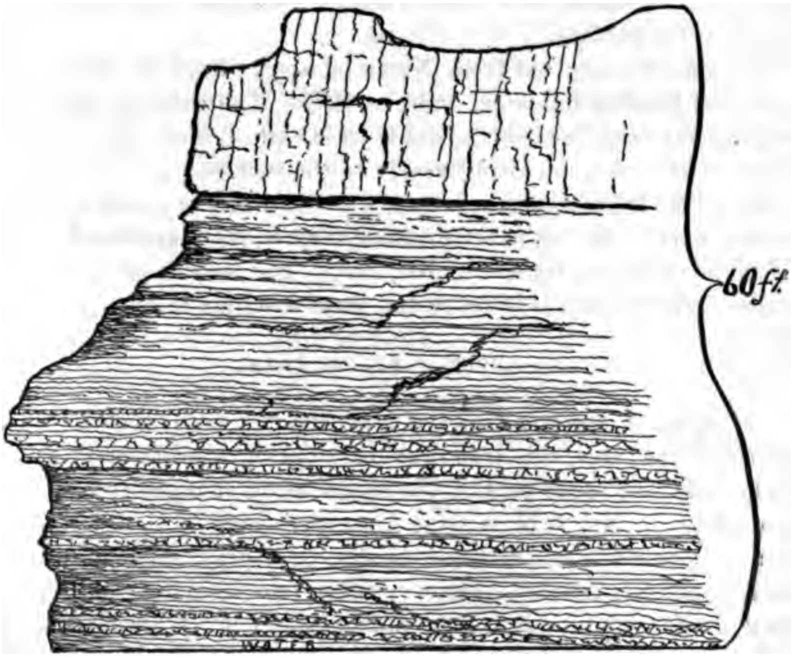

Fig. 9. *Gabbro sheet lying on Animike slate.*

lake,* but not on so magnificent a scale; and the transition seems to be as sudden. This bluff is about 60 feet high. The dip is S. E., four or five degrees. There are continuous sheets of flint, translucent like obsidian, interbedded in the slates. But this does not graduate into the trap although at first surmised to.

Near the mouth of the creek which enters Gunflint lake from the north, at the east end of the long bay, is an exposure of a dark-colored fibrous schist (1278), evidently belonging to a different formation—the Kewatin series of Mr. A. C. Lawson of the Canadian geological survey. This is nearly vertical in its general structure, or dips 85°—88° north, and the strike is E. & W. (true). This is fine and apparently hydromicaceous and softens under the weather. It embraces cubes of pyrite. In the midst of this schist appears rock 1279, somewhat like a dike, which is coarser-grained, sub-porphyritic with feldspathic grains that weather pinkish, is very siliceous, fibrous in the same direction as the schist, and runs about parallel with its prevalent structure. Intimately disseminated through this sub-porphyritic rock are fine scales of a micaceous element, appearing like muscovite but perhaps of the same nature as the finer micaceous scales of the schist. These are so arranged as to their direction as to impart a schisto-gneissic structure to the whole rock.

This exposure is interesting, being the most eastern known locality of the Kewatin rocks in Minnesota, and only about 20 rods distant from some horizontal slates of the Animike, which lie but little further south in such a position as to be necessarily unconformable over the Kewatin.

But a short distance further west gabbro appears at the lake shore in a short exposure, and rises inland.

Again, a few rods further west, appears rock 1280, a part of the Kewatin series, apparently an old eruptive. Gabbro rises high in a ridge immediately inland. This older eruptive (?) is apparently similar to the dioryte and serpentine group of Dr. C. Rominger, seen in the northern peninsula of Michigan, and perhaps is stratigraphically near the same horizon.

Next adjoining this old eruptive rock, is a larger outcrop of Kewatin strata, with gabbro lying on it. It is a gray, compact, felsitic rock, weathering reddish, 1281. It is marked east and west by very evident sedimentation bands, the strata standing about vertical, the aspect resembling that of a transition to "red-rock" seen on the Kawishiwi last year. This, however, is quite another "red rock" from that seen south from Crocodile lake last week. That was very evidently crystalline from a molten condition, but this retains its sedimentary structure, and could have been only plastic. This grayish, fine, felsitic rock, which is not sericitic, becomes hydromicaceous and glistening, or is replaced by such a rock, a little further west, and then it is laminated as if by a fluidal structure, the laminæ being curved and contorted about large quartz grains that are enclosed in the mass. Whether these quartz grains, which have the vitreous structure of chemically pure quartz and are not fragmental, are indigenous to the rock, originally porphyritically generated, or were the result of coarse sedimentation, it is difficult now to say. They are sub-angular, but are frequently elongated east and west, in concordance with a direction of the laminæ (1282).

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* Sketched in 1878.

This pebbly (or porphyritic) structure increases, further west, and the rock becomes firm and more massive, rising in vertical cliffs about 40 feet at the shore, constituting a porphyritic gneiss, the quartz grains becoming more abundant and larger and being accompanied by large crystals of white feldspar, (1283). While here the laminated structure is broken up and lost there is substituted a concordant fibrous and gneissic *rift* pervading the rock, 1283 (compare Nos. 309, 310 and 311, report for 1880). Interbedded with this gneiss is argillitic slate, 1284-5.

There is a green, fibrous rock also seen here, same as 1280, which may have resulted from change in a basic eruptive, which is interbedded with this porphyry and argillyte. It is in thick, conformable beds. It goes down deep and belongs to the same series of strata. It is not in the form of an overflow.

Making a traverse north from Gunflint lake at about half a mile west from the mouth of the river that enters from North lake, unquestionable gneiss, like that already mentioned (1270 and 1274), is met with at about a mile and a half from the lake shore, at a hight from eighty to one hundred feet above the lake. The object of the trip was to see the changes that may take place in the Kewatin toward the north, and to learn the nature and relations of the iron ore said to exist north of Gunflint lake. It proves an interesting section, which warrants the following general statements:

1. All the iron ore we find is in the Animike and near the bottom of those beds. It is not magnetic, so far as seen here, but limonitic through change, though probably hematite (with more or less magnetite) at first. The rock with which it is connected is quartzyte, even pebbly quartzyte—or a rusty, pebbly conglomerate. It lies

about three-fourths of a mile from the lake and strikes east and west. Portions of the rock are flinty and jaspery. We passed a low ridge (not more than five feet high) in the midst of the forested country, and had no favorable opportunity here to observe this ore (312, 1294, 1295).

2. This formation (the Animike) is not seen here in exact superposition on the Kewatin, but all the facts seen warrant the conclusion that has before been announced, that the two formations are discordant.[*] It is probable that the pebbly conglomerate, which is in some places rather a breccia than a conglomerate, separates them.

3. But a short distance further north the Kewatin appears, dipping south at an angle of about 80 degrees. It is made up of, (1), schist somewhat siliceous, but with a silvery sericitic element running all through it, 1296; (2) a coarse sericitic porphyry like No. 1281, 1297; (3) soft chloritic schist, 1298. These are all interbedded, and belong to the same system of stratification, although it is very probable that the greenish schist above called chloritic, is originally of eruptive origin among the Kewatin sediments. This is seen in some places in lenticular beds, and embraces chemical quartz veins. Generally, however, it runs great distances nearly or quite coincident with the bedding and strike of the other strata.

4. About a quarter of a mile further north a great change takes place. The bedded Kewatin is confused and twisted, and though still showing the same rocks, is largely replaced by a micaceous and hornblendic rock (1299, 1300) which itself appears also like a part of the conformable sedimentation. It is comparable to the micaceo-hornblendic portion of the Kewatin which in the report of last year was designated *Vermilion group*.[‡] It lies on all sides of all the above varieties of the Kewatin proper, and also embraces some black hardened argillyte. In this dark-green belt the included "porphyry" is more nearly all crystalline. At a short distance further north the change to gneiss (1301) is complete, or so nearly complete that there appear in it only a few blackish-green, stretched or pressed, boulders and rarely a nearly white-weathering, highly siliceous fine-grained syenitic band, running east and west, uniform in direction with the general strike of all the rocks. Even in this gneiss the same "porphyritic" distribution of quartz and feldspar is observed. The feldspar weathers out in sub-angular grains on the surface, and all the minerals have an elongation east and west. This syenite-gneiss

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[*] The Ninth Annual Report, p. 82.

[‡] Fifteenth annual report, p. 4.

varies, through change in the hornblende, to granitic-gneiss and chlorite-gneiss. At the point reached farthest north it is micaceous.

5. We thus have a conformable transition from the Kewatin changed graywackes and argillytes to the gneiss and syenite of the Laurentian, without any sign of eruptive origin of the latter, the whole maintaining a dip and strike in the same direction, the former being about 80° from the horizon and the latter about east and west.

A trap dike (1303) cuts these beds, running from the syenite south and passing through the Vermilion group, or the mica-hornblende belt. It is 24 feet wide. The advent of this rock is much more recent, and it maintains a massive, undecayed internal constitution.

Making a closer inspection of the rocks of the Vermilion group at this point, they are found to extend north and south about fifteen rods. There is certainly a conformable transition from the Kewatin to this, which is chiefly mica schist, at least superficially. At some depth within the rock perhaps there would be found a greater proportion of hornblende, since it seems that the mica results from the natural decay of the hornblende. The inter-bedded, light-colored rock is the gray "porphyritic" rock of the lake shore, but has some mica scales. It acts here much like the so-called "dikes" of gneiss that are interstratified with the Vermilion group or mica schists north of Vermilion lake. It fades out by very slow transitions into the mica schist, and it also is replaced abruptly by it. It runs to needle-shaped points and vanishes conformably in the darker rock. If it is, hence, eruptive, then this porphyritic rock everywhere is eruptive, and also the schist into which it graduates at the lake shore. Rock No. 1304 shows a blending of the characters of the mica schist with those of the rock that shows the porphyritic characters. The belt from which this came is about ten inches wide, and such are numerous in the schists. Indeed there can be seen almost every kind of transition and every direction of gradation between the schist, the hornblendic rock and the porphyritic and gneissic rock. They all occur as strings and as isolated portions in each of the others. There are belts of coarsely hornblendic rock that alternate several times in the mica schist, conformably with the strike, but the former are confused, lumpy and uncertain. They may have been basic eruptives in the sediments of the Kewatin at the time of their accumulation, and so spread out as sheets approximately conformable to the sediments.

The section foregoing was made on the town line extended north
between towns 65–1 and 65–2, W.
lake Capt. Sedgwick, of Chicago, is

having surveyed out a long tract of land on the north side of Gunflint lake. It is four or five miles long, and from a half mile to a mile in width, and is said to be done on account of the prospects of iron ore on the north shore of the lake. Not far west of the sand-beach, which is at the east end of the lake, but on the north shore, the Animike rises up from below the water, and from below a thin sheet of trap, and is exposed about 2½ feet above the water. It evidently was once covered entirely by gabbro, since that rock is seen immediately overlying, at the same place. Here is an interesting exhibition of the gray rock, so much resembling some gray quartzyte, of which mention has been made in earlier reports. It is very fine-grained, but while it embraces quartz it also contains a considerable percentage of feldspar, or feldspathic material; but the most of the two feet seen is blotched and variously stained gray and rusty. A film of fine rusty rock coats over much of the gray rock, such as has been the cause of much perplexity as to its origin and manner of formation ever since it was first seen in 1878.[*] There seems to be, however, a natural chemical round of changes which gives origin to this film, the initial point being the existence of carbon in the slates of the Animike. These gray layers are associated with thin carbonaceous slates. The two make the bulk of the Animike beds.

Given a black, shaly or carbonaceous rock.

Exposed to the air the carbon is oxidized and slowly forms carbonic acid.

This carbonic acid at once combines with some base, whatever may be present, or any oxide, such as magnetite (which is found present in the Animike here), making a carbonate. In case iron is present it forms siderite which has also been found in these beds in noticeable quantities. This carbonate may be deposited in pre-existing cavities and veins, under the guidance of percolating water, or it may be substituted, particle for particle, for magnetite in the body of the rock, and thus be found to permeate the formation in somewhat the same manner that the oxide does now.

This carbonate of iron is unstable, and immediately suffers the further attack of oxygen, making a quick transition to peroxide of iron, and even to hydrated peroxide. Hematite and limonite would be the next step, and the last, these being perfectly stable except under the operation of mechanical forces, or in the presence of some other acid. The carbonated state is least observable, both as to the time it requires and the space its product occupies. Indeed the transition may be so rapid that the carbonated stage is invisible, and the carbon of the shales itself may appear to act directly on the magnetite converting it to the hydrated limonite.

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[*] Ninth report; p. 62.

There are three stages, and they are all visible at numerous places, and sometimes in the same bed of the Animike.

The first stage is black and carbonaceous (see Nos. 299, 1263 and 1305).

The second stage is gray; sometimes it effervesces freely. It is compact and fine in grain and generally brittle. (See Nos. 312, and 1306, 1307 and 1310).

The third stage is rusty red with limonite. (See Nos. 312, 437, 1307).

This progressive change seems to take place in the slates, where there is probably some magnetite which partakes in the formation of a carbonate. Thus by the aid of carbonic acid magnetite is converted to hematite and limonite, and this may have affected large bodies of ore.

Iron sand appears on the beach at the east end of Gunflint lake.

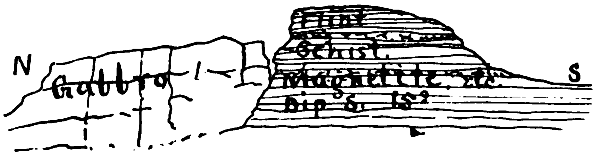

Fig. 10.

The above sketch (fig. 10) illustrates an outcrop on the north side of Gunflint lake, near the lake shore, about on sec. 13 (if the United States system of survey were extended to the Canadian shore), at the east side of a little bay which has a sandy beach. Here is one of the iron localities of the Sedgwick location. The ore here is apparently of very variable quality, some of it being a high grade magnetite (1308), but so far as seen in limited quantities. It is associated with the flinty schist of the Animike, and with a rock (1309) which resembles the olivinitic ore seen last year on the north shore of Birch lake. Fig. 10 shows a mass of gabbro lying next north of a hill of Animike slates, and rising less high than the slates. Such relative positions of these two could be repeated at various other places about Gunflint lake. The gabbro here does not seem to be interbedded in the slates and schists, but to lie on them unconformably. The top of the Animike rocks seems to have formed a zigzag line, caused either by a series of short faultings, breaking the strata so as to present perpendicular cliffs facing north,* or by erosion. Over these bluffs the gabbro flowed, and covered the country. This overflow seems to have followed immediately after the deposition of the slates of the Animike, and to have been partly cotemporary with it, since it is interbedded with them in some places.†

Along the N.W. shores of Gunflint lake are great quantities of rusty rock interbeded with flint, the two alternating in somewhat irregular and lenticular masses or sheets. This rusty rock, sometimes designated quartzyte, is evidently the same that is associated with the ore at 1308 and 1309, and is a form of the so-called "muscovado" rock. Much of this is in loose fragments, and some of it is brecciated and recemented by the rusty rock as a matrix. Compare 1310, 1311.

Some modified forms of the Animike constitute the "muscovado" rock, of the report of last year. This is seen just west of the "narrows" of Gunflint lake (1313), where the same rock is magnetited.

The trap in Animikie bay graduates into, or alternates with gabbro, and also becomes coarsely porphyritic, the large gray plagioclase crystals being embraced in a medium-grained mass, which last has acicular (feldspars ?).

The iron-bearing part of the Animikie, seen on the south side of the point south of Black Fly bay, is a quartz, and flint and jasperoid schist (1315). It is very siliceous, but still associated with the "muscovado" rock. It has a curious, fine, fluidal or streamed structure, and the white silica is chalcedonic. It is nearly horizontal, or tilted somewhat in diverse directions, fragmental, sometimes pebbly. It is fine, sometimes with bands of red jaspilyte, and sometimes with considerable magnetite.

North of this, as if underlying it, is a bluff of slaty Animike: and across the bay next north, is the Syenite range (1316), without any Kewatin intervening. This indicates either that the Kewatin is wholly changed to syenite (Laurentian ?) or that the Kewatin beds seen so conspicuous on the lake shore a few miles further east, and extending for half a mile north of it, run below the Animike as they pass toward the west. Either hypothesis would demonstrate the *non-conformity of the Animike on the Kewatin*

The syenitic gneiss on the north side of Black Fly bay (1316) is like that seen north from the Kewatin and Vermilion groups, on the traverse made northward from Gunflint lake (1301). It has here a strike E.

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* Is suggested in the seventh annual report. p. 15.

† See, later, the geology of Chub lake, west from Gunflint lake.

5° S. and seems to lie south from the strike of the Vermilion rocks.*

It is a very remarkable fact, however, that toward the north here there can be seen nothing of the rocks of the Vermilion group. There is almost a continuous rock exposure along the river leading toward the north, and to Saganaga lake, and nothing but syenite is seen. The mica-hornblende series is conspicuous wherever it exists, and it could not cross this river without its being observed. It is necessary to infer, therefore, either that the strike changes so as to bring the Vermilion belt in its westward extension, underneath the Animike at some point between the narrows and the place of making the traverse already described, or that the whole is converted into syenitic gneiss, with no micaceo-hornblendic stage preserved. This gneiss is like that seen to come on by a change in the Kewatin, already described. It is not perfectly crystalline, but parts are left with only an amorphous crystallization, or the feldspars and quartzes are imperfect, crowded and shapeless, but always elongated east and west, in the direction of the strike. Some of the quartzes are an inch and a half long, but no more than a quarter of an inch wide, but generally they are about half an inch long and an eighth inch wide, being rather lenticular lumps of quartz than crystals. Their forms stand out prominently on the weathered surface. The third ingredient of this syenitic gneiss, which seems to be originally and generally hornblende, becomes chloritic, hydromicaeous, or muscovite, this difference being due probably to some extent to an *a priori* difference in the sediments, but also largely to a difference in the degree of exposure and decay. The structure is vertical.

A striking fact in connection with this gneiss is the enclosure of masses of hornblendic rock, i. e. of long and lenticular patches in which the dark hornblende is much more abundant than any other mineral. This appears on the upper surfaces and on the eastward facing bluffs, showing they are of short extent, the longest not being more than eight feet east and west, and the thickest not more than eight inches from north to south. They cease by running to points and thin edges and fading out. This dark rock is the same as the rock in the Vermilion group as seen further east, and it may be the vanishing point of that group.

The Vermilion group at Gunflint lake.—Owing to the importance of the question—what becomes of the series of dark schists (the Vermilion group) in its extension toward the "narrows" I sent back Mr. F. N. Stacy, with one man, to make special search for it, and for its manner of disappearance, with directions to make excursions north from the north shore of Gunflint lake across the strike of the rocks until he found what becomes of it. Two such excursions were made, one nearly on the line of extension north of the line between secs. 26 and 27, and the other nearly on the line of separation between secs. 25 and 26, if the same were to be extended across the lake into the Canadian territory. It seems from the search of Mr. Stacy that this series of strata ceases rather abruptly and is replaced by the syenitic gneiss of the region; but what are the facts of its manner of disappearance, it is not yet known.

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*According to my brother's observation the strike of the structure of the gneiss at the first falls of Boundary river, about 1½ miles north of Gunflint lake, is 10 deg. N. of E. (mag). The variation supposed not to exceed 5° E.

Following is Mr. Stacy's account of this search. The specimens he obtained, to illustrate his trip and notes are numbered from 1457 to 1500, both inclusive, and are described in the appended list of rocks collected.

The "Black Belt" of Gunflint Lake.

The following is an account of two short inland excursions from the north shore of Gunflint lake, Sept. 7, 1887, by F. N. Stacy and Charles Sucker. Two days before, Sept. 5, the geological party under Prof. N. H. Winchell had discovered a conspicuous "black belt" of micaceous and hornblendic schists about three-fourths of a mile north of the lake on the north and south town line between 65-3 and 65-2, W. (Am. Surv.). The object of the excursions of Sept. 7 was to find what had become of this black belt in its westward extension.

The first landing was made just north of "Gabbro" island, about two miles west of the above mentioned landing, Sept. 5. The out-cropping rock on the shore at this point was a light gray slate of a nearly perpendicular dip, and of a nearly east and west strike. Parallel with the lake-shore for three-quarters of a mile due north, successive bluffs of slates and other perpendicular schists of the Kewatin group, sometimes cut with igneous dikes, were crossed at a gradual increase of elevation. Until at a distance of nearly a mile from the lake, and at an elevation of about 200 feet above the lake-level, the Kewatin was discovered over-capped with gabbro. North of this was a steep decline into an extensive swamp, with no further out-crops for half a mile farther north, and the search for the black belt at this point was discontinued.

Failing to find the black belt in this first inland excursion, a second landing was made about one mile further east, and mid-way between the excursion just described and that of Sept. 5. At the second landing, also, the Kewatin cropped out at the shore-line. But when first met at this point, the Kewatin was a "porphyrel" —a micaceous, sericitic schist with feldspar crystals between the laminæ. In the journey due north, next came cherty schist, then slate, followed by sericitic and micaceous schists, and, by gradual transition, the usual members of the Kewatin group; until at a distance of about three-quarters of a mile from the shore appeared the "black belt" of hornblendic and micaceous schists. These in turn

> were followed in the usual order by the gneissic and syenitic rocks. At a distance of about a mile and a quarter north of the lake, and at an elevation of about 250 feet above the lake-level, was found in the topmost bluffs a typical Saganaga syenite.
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> The "black belt" as thus discovered appeared to be in the direct strike of that found further east on Sept. 5, but was much broader in extent and higher. The narrow beds of two days before, lying in a single bluff, had widened out into a series of parallel bluffs from one hundred to two hundred feet elevation above the lake-level. These bluffs of varying micaceous and hornblendic schists rose in successive parallel terraces for over a quarter of a mile north of where first discovered, until finally merged into the syenite which formed the broad-backed summit. In its extension a half mile westward the ridges of the belt appeared to be cut off by low and swampy ground.

In the absence of definite information as to the disappearance of this "black belt," Mr. U. S. Grant was directed in July, 1888, to make further search, on the occasion of a visit to that region. His report is not rendered yet, but in a letter from the field he states that he traced it westward to within 200 feet of a range of syenite hills from which it was separated by a swamp, and the manner of contact could not be observed.

Further west, as will be stated more fully later, on the west side of the "narrows," this belt of mica-hornblendic rocks appears again and constitutes an important member of the series of the region.

As to any unconformity between the so-called "crystalline schists" and the Kewatin graywacke and the associated porphyroidal rocks, nothing is seen of it about Gunflint lake. On the contrary all that is visible indicates a conformable transition, by gradually changing proportions of minerals, aggregated in beds that are everywhere conformable, from the Kewatin to the Vermilion group. It is true, however, that the appearance of distinctly micaceous and distinctly hornblendic beds, is different from anything seen in the other portions of Mr. Lawson's Kewatin.* But with this appearance continue the same kinds of beds as in the graywacke belt, alternating with these micaceous and hornblendic beds. But when these darker constituents appear there seems to be a more complete crystallization of all the parts, the porphyritic laminations approaching nearer to crystalline gneiss, and being less sericitic. There is here a progressive crystallization from the graywacke and sericitic schist, through the schists of the Vermilion to the gneiss of the Laurentian; there seems to be no more reason to place the Vermilion group with the Laurentian there is to place it with the Kewatin.

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* It should be remembered that Mr. Lawson's definition of Kewatin makes that group embrace the Vermilion group; but frequently in this report the term Kewatin is used in a restricted sense by omitting the "black belt," and the term Vermilion is applied distinctively to the "black belt."

While there is this gradual transition, so far as can be seen, from the graywackes into the Laurentian, there is yet reason to exempt the greater part of the Vermilion group from the ordinary sedimentary methods of accumulation of clastic rock. It appears to have been introduced in some places and not in others. Its composition will allow of its having been of eruptive origin among the sediments of Kewatin time, in some such manner as the eruptive beds are seen introduced and interstratified with the Cupriferous. Indeed it is believed now to have marked one of the early, if not the earliest, general outpourings of basic eruptive rock. It was embraced into the strata of the then forming crust, and was disposed with general conformability between the underlying, older, sediments, and the later graywacke belt. It has suffered the upheavals and pressures and displacements that the other strata have experienced. It has been turned up edgewise, like them, but it has maintained its distinctive character and its general stratigraphic integrity. On the side toward the gneiss, which would naturally be the bottom of the overflow, the transition from the Vermilion group is sometimes through a series of fissures, veinings, dikes, and included masses, indicating an epoch of disturbance such as would allow the escape of molten rock, while on the side toward the Kewatin graywackes the transition is one that indicates a sedimentary mingling and interstratification of graywacke debris with debris from the eruptive rock last poured out. These alternations are sometimes very numerous, but gradually the micaceous (originally hornblendic) element fades out, and the well-known graywacke element only remains.

West from the "narrows" extends Animike bay, a spur from Gunflint lake. Ascending the point north from this on the north side of the point, thus passing from the gneiss across the strike of the Animike up to the gabbro which forms the summit of the point, an outcrop of rock is encountered such as has been seen frequently near the contact of the gabbro on the other rocks, and which has been styled, in some of its aspects, "muscovado," but here it is finer, and has a siliceous frame-work instead of siliceous grains (1319).

It passes into a siliceous (streamed?) gray rock, evidently fine-bedded and not wholly siliceous (1320).

And in immediate contact with these, sometimes one and sometimes the other, is considerable magnetite which probably here becomes valuable as merchantable ore (1321) The needle is wild; not much is visible, but it is in place, and might be in large quantity.

Passing further south, on this point, I meet with a great many large fallen masses of freshly broken (not rounded) gray, coarse quartzyte, or grit (1322), evidently derived from some portion of the bluff which here rises about 100 feet higher and faces toward the north.

At the top of the hill is gabbro (1323), but in places it is fine-grained. It is distinctly basaltic, and in some places takes the form of a coarse porphyry like 1314.

Sample 1324 is a fine black slate, nearly horizontal, from near contact with the gabbro, north of Animike bay, but slightly changed. In this black slate one can imagine, from the forms seen on the bedding surfaces, that he sees encrinites, ostracoids, climactichnites, fucoids, and mammillated or finely pitted surfaces that recall the rough plates of some large fishy reptiles. But so far as I can see these shapes are all of mechanical origin. They do not seem to warrant the unqualified statement of organic remains in this rock. Still it is very probable, judging from their carbonaceous composition, their finely slaty sedimentation, and the preservation of fine ripple-marks (1385), that life existed, probably animal life, at the time of the gathering of these sediments, and that real organic remains will be discovered in them sooner or later.

At Iron lake, at the old Mayhew location, 1287 represents the so-called changed quartzyte, on which the gabbro lies unconformably. This now seems to be the "muscovado" of last year. The gabbro is unmistakably on it unconformably. 1291 is a specimen of the iron ore at Iron lake.

Rock No. 1293 is from a boulder, north shore of Iron lake. The interesting feature in this boulder, which was rounded, and evidently far transported by drift agents, is that *it is made up of boulders.* Originally the mass measured 3 ft. by 2½ ft. by 4 ft., and by the action of fire large slabs have been made to drop off. Otherwise no samples could have been obtained with any means which we could control. This is not only made up of boulders, but it is from the mica-hornblende schist or Vermilion group, and shows that conglomerates there have been converted into crystalline rock. The small boulders are of greenstone, mica schist and changed greenstone. The matrix is granulyte or granite. Later the Vermilion group rocks have been seen and described as conglomeritic by H. V. Winchell, just east of the entrance to Black bay on Rainy lake. (See his report in this volume.)

The conglomeritic structure has therefore now been seen in the following crystalline rocks in Minnesota:

1. The Sauk Rapids "granite."
2. The porphyritic conglomerate at Ogishke Muncie lake, and the similar gneiss in Kekekebic lake.
3. In the Stuntz island porodyte.
4. In the greenstone of Twin mountain.
5. My brother reports it conspicuous in the Saganaga granite.
6. This boulder shows it in the Vermilion group. (Since this observation was recorded, an examination has been made of the gneiss quarries at Morton and Redwood Falls, in the Minnesota valley, where this structure is very common and conspicuous. This gneiss is certainly in the southwestward extension of the Vermilion group of the northern part of the state.)
7. In the "Laurentian" syenite in Michigan, south of the Aurora mine.

ACROSS THE COUNTRY FROM GUNFLINT LAKE TO OGISHKE MUNCIE.

In the report for 1881, p. 95, in reporting the observations made in the region of Gunflint lake in 1878, some reasons are given for considering the "quartzyte-slate formation" seen at Gunflint lake (the Animike) in horizontal position, the equivalent of the great quartzyte and slate formation at Ogishke Muncie lake which passes into the Ogishke conglomerate. But the matter was not settled, and has been ever since an element of uncertainty which has entered into every attempt to establish a systematic stratigraphy for the oldest rocks of the state. At that time the tilted schists and graywackes of the Kewatin series, with their contained iron ore, were considered an integral part of the same tilted series as the slates and quartzytes associated conformably with the Ogishke conglomerate; and the iron ore of the jasper ridges at Vermilion lake were considered the equivalent of the iron ore seen in the Animike. This is the view that was adopted and subsequently urged by Prof. R. D. Irving. But since the separation of the Animike from the Kewatin has been established by marked unconformities, and by constant differences in lithology (including a constant difference in the kind of iron ore associated, and their respective mineral accompaniments), it remained still to answer the question—To which series, the Animike or the Kewatin, does the quartzyte-slate-conglomerate of Ogishke Muncie lake belong? The report of last year (the 15th) leaves this question unanswered, although stating (p. 381) on the authority of some general parallelizations, that "the Ogishke conglomerate is allied closely with the Animike. It contains numerous greenstone boulders, and perhaps represents its basal portions."

In order to trace the strata from Gunflint lake westward a trip was planned through the country, leaving the Boundary waters at the west end of Gunflint lake, and reaching Ogishke Muncie lake by way of Gabemichigama lake and Fox lake.

Going west on the section line between secs. 24 and 13, 65-4 W. to the N. W. cor. of sec. 23, thence south, and a little east, a recent iron-working is found. Here is a low, northward-facing Animike bluff, not exceeding 18 feet in hight, the strata dipping southeastwardly about 12 degrees, made up of ore on the top (1325 and 1326) about 5 feet, and of alternating gray grit and sandstone, with some ore and chert, below (1327). This ore and the rock associated, resemble those of the north side of Gunflint lake, as well as those seen in the Mesabi range and reported on by Prof. Chester (11th annual report). It is but little south of the gneiss range (the Giants' range) in all three places, and appertains to the same stratigraphic plane, *i. e* , near the bottom of the Animike. No gabbro is visible here; the general slope is toward the south. This iron has been uncovered by exploring parties at several other points further east.

A little south from the face of the bluff a shaft has been sunk into this rock. It passed through the ore-belt, into the grit-stone and chert, and struck gneiss within ten feet from the surface. This gneiss is mainly gray, but some of it is reddish, having orthoclase. The shaft penetrates it about two feet. Between the Animike rocks and the gneiss is a thin layer (one or two inches) of yellowish rotted earth and rock. This ore, lying in a sheet, dipping but little to the S.E., should be taken up by the acre. On a forty-acre tract there would be many tons, but it does not go deep, like the ore at Tower, and in that respect this ore differs uniformly, so far as known, from that in the Kewatin rocks. This location was discovered by Henry Mayhew, and the working has been prosecuted by Messrs. Paulson, Barker, Boyden and Millar. Of this ore Mr. Millar gave me the following result of analysis, made by Rattle and Nye, Cleveland.

Metallic iron	55.600
Silica	10.020
Phosphorus	0 042
Manganese	4 340
Alumina	0.340
Titanium	none.

This shows a high grade ore, but very likely the sample was selected with reference to getting a good result, and that the five feet of ore seen would not average as good.

South from the place of this pit about half a mile is another range of magnetited rock, and the amount of ore there would be likely to be greater than at this place. This ore is fine-grained, compact, magnetic, indistinctly banded and everyway similar to that seen in Towns 59 and 60 on the Mesabi range, and unquestionably is in the same formation.

This unconformable position of the Animike on the gneiss is conclusive against the idea of the identity of the Animike with the Kewatin rocks, and also against their conformability, and effectually establishes the distinctness of the Kewatin from the Huronian of Canada,[*] the Huronian being the equivalent of the Animike and the great quartzyte that overlies it.

Further, the existence of this gneiss, which is the same as seen in the Giants' range just north of this point, at places so far south, in line of the strike of the Kewatin beds that have been described on the north side of Gunflint lake, indicates some change in the Kewatin, introducing an irregularity in the line of strike. It is possible, indeed it seems probable, in the light of facts which have been mentioned showing the variableness of the lithology of the Kewatin toward the greater crystallization of the adjoining gneiss, that there is an encroachment of the gneissic characters upon the schistose, and that the Kewatin beds seen north of Gunflint lake are changed by intensified metamorphism to the gneiss that here exists in the line of strike from there. In this gneiss occur isolated masses of a darker hornblendic rock similar to those masses already described north of Black Fly bay. A great east and west dike of greenstone seems to cut this gneiss just north of this working, but it makes only one or two slight exposures, so far as seen on section 23.

But following the trail that runs west along the north side of sec. 22, this great greenstone dike becomes visible on the north side of the trail about an eighth of a mile west of the section corner. This is in 65-4. Rock 1329 is a sample of this dike, seen on the north side of the trail. Large detached masses have fallen from the cliffs which rise precipitous along the north side of the trail. The direction of the dike, if so it may be called, is about 15° south of west. This sample is like gabbro, and does not correctly represent the nature of this greenstone. See rather 1330 and 1331.

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[*] This unconformity has been described by A Winchell in *The American Geologist*, January, 1888, p. 23. Compare also the paper by the writer in the same number of *The American Geologist* (p. 11) on the equivalents of the original *Huronian*.

The Giants' range, which is crossed by the section line, runs southwest at this place, and where the trail leaves it the descent seems to be about 200 feet.

Again, a little north of the quarter-post between secs. 20 and 21, 65-4, a greenstone display appears. It rises in a vertical wall facing north, and is crossed by the section line. It is somewhat weathered to a schistose rock, sometimes chloritic, on the exposed angles, but within it is a massive, fine-grained greenstone. Rises 45 feet about vertical.

Re-examining this vertical cliff, the schistose structure is seen to run W. 15° S. (mag.) which is also the general direction of strike of the rock-mass. There is no appearance of sedimentary bedding. It may be a revival of the crystalline schist belt seen on the north side of Gunflint lake, which was seen also to disappear rather abruptly by the interposition of light-colored gneissic rocks of that region. This certainly has the aspect of much of that, but it lacks, so far as can be seen, the sedimentary banding which is common in some parts of that.

Traveling south from the face of this cliff, about 200 paces, evidently all the way over the surface of the same rock, at a low crest where a descent begins toward the south, the rock 1332 is seen, plainly identical with 1330. Superficially it has a schisted aspect, but it is massive within. It does not show any sedimentary bedding—only thin seams and veins reticulating through it, of lighter minerals, in which probably is some quartz. But generally throughout this rock quartz cannot be distinguished.

South from the last is another vertical wall, about 12 feet high, just east from the trail-crossing containing the same greenstone (1333). This is after passing a swamp about 30 rods across. This ridge descends abruptly to a low east-and-west valley, after which another of the same rock rises still higher, perpendicular, about 25 feet, repeating the phenomena seen in the same kind of rock last year north of the Kawishiwi river (15th annual report, p. 346).

The iron location on Chub lake, N. E. ¼, N. E. ¼, sec. 29, 65-4. At the northeast end of the southerly of the two lakes (on the surveyor's plat wrongly included in one lake) is a recent iron exploration. This working was done by the same parties as already mentioned in connection with that on sec. 23 in the same township, and from Mr. Millar were obtained the results of assays made by Little and Nye, of Cleve-nd, as follows:

	Met. ir'n	Silica	Phos.	Mang.	Alum.	Titan.
No. 1	58.40	8.22	.036	4.92	.52	None.
No. 2	54.01	9 37	.032	5 02	.07	None.
No. 3 (average of 6 samples)	63 98	8 90	.028	None.		Trace.

This ore is well characterized olivinitic, magnetic, granular, the yellowish waxy grains of olivine being mingled rather uniformly with the grains of magnetite (1336). It easily disintegrates and in favorable situations would give origin to iron sand.

The greenstone represented by 1330 and 1333, already described, extends southward indefinitely, occupying a tract of elevated rough country, timbered heavily with pine and spruce, and covered under foot with northern mosses. This elevated tract descends southwardly to this iron location where it is evident that the geology has changed, and the greenstone has given place to the Animike carrying magnetite. The most southern identifiable portion of the greenstone is represented by rock samples 1834. There is then a transition, in traveling south to the iron-location (what its nature was could not be ascertained owing to the vegetation, although the ground was searched over twice), to a rock represented by No. 1335. But judging from all that could be seen this rock lies upon the greenstone. It has some resemblance to the greenstone, but is blotched alternatingly with basic dark and acidic light minerals; it is hence somewhat lighter colored. It has a heavy, bedded structure which, however, does not show any evident sedimentary characters, but which is more like that of a massively bedded eruptive, or like that seen in the gneisses of the Laurentian. This bedded structure dips southward at an angle of about 45 degrees and approximately conformable with the dip of the Animike rocks carrying the iron ore, and runs under the iron bearing beds. The exact manner of contact was not seen. This rock has not the free and completely crystalline characters which indicate an original eruptive or a completely re-fused sedimentary rock. It appears rather to have been produced by a metamorphism *in situ*, of some sediments which contained a large amount of basic material, this change having taken place by hydro-thermal fusion when the sediments were yet deeply buried in the super-crust. Such a rock, so far as known, has not been seen before in Minnesota. Its geology should be further examined into before any positive statements can be made concerning its origin and relation to the greenstone on which it seems to lie, or to the Animike quartzyte under which it seems to lie. It seems to be no part of the Animike unless greatly modified. It is not slaty, nor flinty, nor evidently fragmental, but crystalline and of a medium grain. Toward the north from the iron-pit this rock rises in a hill to about 175 feet and breaks away precipitously; and another lake, elongated E. and W., lies at the foot of the bluff on the north, north of which, and about which, greenstone like 1334 only appears. Indeed the greenstone seems to come out at the top of the hill on the northern side, and the specimens No. 1334 are from there.

At the ore-pit the working was done by sledges and crow-bars, apparently without any blasting. The excavation is only about ten feet deep, and passes into the layers near the level of Chub lake, in a northward direction, and hence toward the underlying metamorphic rock No. 1335. But, what must have been a surprise to the explorers, and perhaps caused the stopping of the work, the ore beds (1336) are found, at the depth of about 10 feet, to lie on loose sand and boulders, exactly like those seen in the drift round about, the boulders being of gneiss and greenstone (1337). The sand is clean and crumbling, like lake sand. Some of the gneiss boulders are a foot in diameter, and of the greenstone at least six inches. There is on the top of this sandy and bouldery layer a kind of blackish or brownish soil-like rustiness which probably results from the rotting of the olivine in the overlying iron deposit. So far as seen the whole thickness is about twenty inches, but its depth is not shown. This gravel and sand was thought at first to be the equivalent of that seen actually between the Animike and the gneiss on sec. 23, already described, but on making further examination it was found that it more likely is a part of the prevalent drift that covers the country. It is necessary to suppose, if this hypothesis be correct, that the iron-ore beds penetrated by the excavation are only the low remnant of a cliff facing north, and that the hill which rises next north from the cliff, sloping southward under it, presented, at the time of the drift epoch, a sudden projecting jog or step behind which, and below which, this gravel and sand had accumulated, filling the depression up so as to make the hillside appear smooth. All semblance of such a jog, however, is lost, and its existence is invoked in order to explain the anomalous position of the sand and gravel.

The geology of these iron-bearing strata is quite interesting, as it reveals some new points respecting the Animike, and may be condensed as follows:

1. The beds are a part of the Animike, and dip south about 30°. They contain a considerable amount of grit. This grit is like that

seen disseminated in the Animike at Gunflint lake. It is largely quartz, but is mingled with olivine and magnetite.

2. The iron-bearing rock passes into a gray quartzyte like that seen north of Animike bay (1322).

3. North of this working is a great thickness of some changed sedimentary rock (as supposed) on which the Animike seems to lie, the hill rising 175 feet above Chub lake (1335). This changed sedimentary rock resembles somewhat that seen at the N. E. end of Gabbemichigama lake, described on pp. 379 and 380, of the report of last year, and perhaps is the equivalent of some of the so-called muscovado rock seen unconformable below the gabbro.

4. It lies to the south of a great greenstone range, the same as supposed last year to lie under the Animike, over which, by its dip, reaching sometimes 45°, it must have passed if formerly extended northward.

5. The quartzyte with which the ore is associated becomes developed, at about one-eighth mile further west, into a sharp, prominent ridge, which faces perpendicularly northward, the beds dipping 48° south, the quartzyte itself and magnetic quartz schist being from 140 to 150 feet thick, and the associated olivinitic ore beds being perhaps 50 feet thick. There is one layer of hard vitreous quartzyte (1338), very heavily bedded, which is at least 20 feet thick.

6. Inter-bedded with this quartzyte (1340) is a layer of gabbro (?), near the top of the ridge (1341) which varies from the typical gabbro of the Mesabi in being fine-grained and more like some of the muscovado beds. It is also coarsely porphyritic with a dark striated feldspar, apparently labradorite. This porphyry recalls that seen at Gunflint lake, No. 1314. The appearance of some of the thin layers of basic material seems to indicate that they were immediately followed by coarse sediments of almost pure silica (1339).

7. This inter-bedding seems to fix the age of at least the beginning of the gabbro overflow, and since the great body of the gabbro overflow is found to cover the small islands very near the north shore of Chub lake, there could not have been much interval between this beginning and the great development.

8. This rock and ore have a frequent jointage perpendicular to the dip. This causes it to break under the weather into cuboidal small blocks, the bedding being about four to six inches thick. It also gives the ore a fibrous structure under the action of which it is more easily broken across the sedimentation than in any other direction. It is this easy cuboidal disintegration that has caused it to occupy,

at the present time, the lower parts of the country, rather than the higher, the drift agents and subsequent drainage and erosion having removed it.

9. There seems to be a large amount of ore connected with this formation here, and it will probably ultimately prove valuable.

10. This great quartzyte, being near the top of the Animike (whether conformable on it or unconformable is now unknown), is a new feature in this part of the state, and is worthy of a name. In the field book it was named *Pewabic quartzyte*, from the Chippewa word meaning iron. It apparently occupies the same horizon as the quartzyte at the head of Wauswaugoning bay; which again is supposed to be the equivalent of the Thessalon and Otter Tail quartzytes of the original Huronian; which again, as the reader will have learned who has followed this report, is regarded the same as the quartzyte north of the Adirondacks in New York which has been named Potsdam.

In passing from Charley lake, in sec. 32, 65-4, to Flying Cloud lake, in sec. 25, 65-5, there being no regular route, we follow some trappers' and other dim trails. As the plat is unreliable as to the size and shape of the indicated lakes, it is impossible to identify some of them along the route we took. We travelled wholly on gabbro, and saw nothing of interest except when passing westward along an old gabbro valley, about S.W. ¼ of sec. 30, 65-4, in which the gabbro walls rose on each side nearly vertical, though the width of the valley was about one-eighth mile. On the south side as the canoe was pushed through the brush down a little ravine that runs from one lake to another, signs of violent and copious flow of water—indeed nothing but a glacial river could have formed the pot-holes which are sculptured on the gabbro thirty or more feet above the level of the present creek.

Passing north from Flying Cloud lake, which is in the southern part of sec. 25, 65-5, on the east side of the outlet, after passing a short distance on the usual gabbro surface, a low ridge of reddish gneiss is seen (1342), near the lake shore, rising up through the gabbro. This gneiss is distinctly layered, and dips N. 30° W., at an angle of about 30 degrees. Continuing this traverse northward toward Bingoshick lake, gradually ascending, near the center of the N. E. ¼ of the S. W. ¼ of sec. 25, 65-5, the iron-bearing rocks are met again in the appearance of the Pewabic quartzyte.

At first it is not conspicuously exposed, but is distinctly magnetic and granular. It dips 55 degrees towards the south, and strikes about east and west (E. 8° N.).

A short distance further north these quartzyte beds break off toward the north in a vertical cliff about 135 feet high (1343). It dips south as before, and probably fills the whole interval between that first exposure and this. The thickness of the bedding that can be made out thus is about 300 feet, and it may reach 500, as it can be seen also further north, and across a swamp that next supervenes. It appears as if at this place most of that quartzyte seen at Chub lake in separate ridges is gathered in one cliff.

About midway in the bluff is a bed of porphyritic gabbro (?) about 8 feet thick (1344), but in general the cliff is made up of quartzyte.

Before reaching the south shore of Bingoshick lake the same rock as seen north of the iron working at Chub lake returns (1345), but just at the lake is a greenstone (1346), or a dark, gabbroloid greenstone. These two rocks, 1345 and 1346, seem to have close and perhaps intergrading relations; and perhaps cannot be separated, but No. 1345 seems to be lighter colored and to contain some free quartz. They are both found to the north of the strike of the Pewabic quartzyte, and from north to south the belt they occupy is here half a mile wide. As compared with the schistose and micaceous greenstone seen in the W. part of sec. 23, they are more massive, more fresh, and more gabbrolike, i. e. they more nearly approach the rock that has been denominated muscovado in the fifteenth report.

Observed positions of the Gabbro.

Gabbro lies on the Animike at many places.

Gabbro lies on the Pewabic quartzyte at Chub lake, and is interbedded with it. The same is true north of Flying Cloud lake.

Gabbro lies on the Kewatin north of Gunflint lake.

Gabbro lies on the red syenitic gneiss north of Flying Cloud lake.

Observed positions of the Animike.

The Animike lies on the Kewatin unconformably, north of Gunflint lake.

The Animike lies on the gneiss in sec. 23, 65-4.

The Animike (Pewabic quartzyte) lies on the rock 1335 on the north side of Chub lake.

Relation of the Pewabic quartzyte to the Animike.

This magnetited quartzyte, which apparently is near the top of the Animike, and lies on the greenstone belt represented by 1345 and 1346, seems to extend further north than the great mass of the Animike rocks. If this relation be correctly made out, and if the greenstone be older than the Animike, it would be necessary to suppose the quartzyte was deposited during a period of increasing submergence. Thus the older sediments would be hid by the encroaching shore-line, and on upheaval might not appear at all in their proper place between the quartzyte and the greenstone. Not enough is known, at this time, concerning the stratigraphic position of this quartzyte, and the relation that rocks 1345-6 may bear to each other and to the greenstone that constitutes Twin mountain (see report of last year, p. 373) to warrant any conclusion on the exact statigraphic position of the quartzyte. Unless there be a fault running east and west through the point which is north of Animike bay, there are some thin Animike slates separating the main gabbro sheet from this quartzyte—i. e. from *some* quartzyte which is supposed to have given origin to the masses found on the north side of the point (1322).

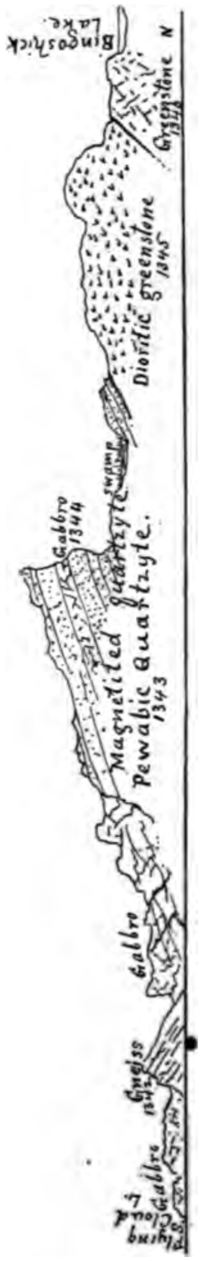

Fig. 11. Section north and south from Flying Cloud lake to Bingoshick lake.

The section represented in fig. 11 indicates the succession of rocks passed over between Flying Cloud lake and Bingoshick lake, sec. 35, 65-5, except that the gabbro area should be lengthened out and the quartzyte diminished. Probably gabbro occupies one-half of the whole distance.

In passing through *Muscovado lake*, the large lake in sec. 36, 65-5, we gave it that name because of the peculiar character of the rock which forms all its shores. It is represented by No. 1347. It is much decayed, and finely granular, having nearly the color of muscovado sugar which last year suggested the term. This color is assumed by decay, as is shown by one of the specimens, the interior color being gray, like real gabbro. This rock takes on a conspicuous bedded structure. It sometimes looks like a fragmental schist, the beds being only one or two inches in thickness, and the schistosity being fine and causing the cliffs to crumble. Indeed, except that all the rock here is fine-grained, this region exhibits the repetition, or extension of the phenomena of Wilder lake, seen last year (15th report, p. 350), where there seems to have been no transporting or eroding drift-action. It is considerably higher than Bashitanakueb lake, perhaps 75 feet.

The laboradorite rock on the south side of lake Bashitanakueb is represented by 1348. It is similar to the white-weathering gabbro of Little Saganaga lake.

There is a notable difference in the manner of decay between the greenstone and the gabbro, indicating some fundamental difference in origin and history. The former makes a chlorite, fissile schist and disintegrates (1349). The latter becomes schistose, but not chloritic. It crumbles to pieces as its constituent grains are loosened and they separately decay, making gravelly soils in many places which sustain the forests.

About Bashitanakueb lake are a few foreign boulders of gneiss, and others are on the portage northward to Kakego lake.

GABEMICHIGAMA LAKE.—THE ANIMIKE.

In passing again round the point in Gabemichigama lake (sec. 32, 65-5), which is illustrated in last year's report (p. 380), an opportunity was offered to compare some of the outcrops on the north side with some of those seen further east, and particularly with those at Chub lake. From this re-examination the conclusion was reached that the beds seen in the point are probably changed Animike. Much of this rock is fine-grained, and siliceous, and some of it is plainly fragmental, though now it is mainly crystalline. In its general aspect it very much resembles the rock 1347, and may be the same. In some of the fresher parts (1350) it shows an apparent alliance with rock No. 1345,—that on which the Pewabic quartzyte lies. At least, that it cannot belong to the vertical slates (or the *Kewatin*) is very plain. It is not magnetited, but it is tilted and broken, and was probably once covered by gabbro which exists in abundance but little further east, and rises in the hills that form the main shore of this part of the lake.

Still further toward the N. E., on the S. W. ¼ of sec 29, 65-5, just across the section line, is a vertical cliff, facing the lake, about 14 feet high. The evident sedimentary bedding dips at an angle of 45° toward the E. 40° N. This is distinctly sedimentary, because fragmental, banded and tilted like a sedimentary rock. It is very fine-grained generally (1351), and argillaceous, but on some of its weathered surfaces it has a light rusty coating about a quarter of an inch thick, covering the pale blue within, as if it were some of the Animike changed by the process noted at Gunflint lake, and further hardened and consolidated by the metamorphism due to upheaval and igneous contact. Rocks 1352, 1353 and 1354 are more coarsely fragmental portions of the same, 1353 being a gray grit, mainly feldspathic, but with evident grains of pure quartz. Near the lake level this rock is immediately overlain by a small mass of gabbro in place.

Going still further east, and northeast, about half a mile (in sec. 29, 65-5), the gabbro appears in the highland extending north nearly as far as the north end of the lake; but near the lake a bold bluff of hardened and tilted Animike, dipping as stated toward the east, runs northward. This varies from grit to blue-black, siliceous rock (in some of my earlier reports designated gray quartzyte), and is fractured and twisted so as to cause a curious mingling of fine and coarse-grained rock. This extends as far as I went north. This condition (except the much broken stratification) and this rock, can easily be recognized as a part of the Animike, and this observation confirms the doubtful inference of last year. I did not follow it far enough northward to reach the belt of greenstone which supervenes but a short distance further north. This rock differs from the Kewatin in these respects: It does not show any vertical cleavage and slatiness, but is slaty, where not too much altered, in a direction coincident to the sedimentary seructure (1355); it dips in massive beds (resulting probably from a consolidation of the original Animike slates), and in some thinner, more coarsely gritty, in a direction different from anything seen in the Kewatin; it lies to the south of the great greenstone belt; it continually changes its dip and strike, and it seems to have an insensible gradation toward the so-called muscovado rock, which itself is both in massive beds and in thin ones, and is even seen to be a part of the stratification in the Pewabic quartzyte, with which the magnetic iron ores are connected.

The hills about the N. E extremity of Gabemichigama lake consist entirely of the Animike, fine-grained, tilted, fractured, recemented, but in general dipping northeasterly. At the lake shore these beds weather out very rough, the siliceous veins and the harder beds projecting. In some places they are about vertical, but they vary constantly in dip and strike.

In passing along the north shore westward, however, N. E. ¼ of sec. 31, 65-5, this rock becomes slaty and vertical, and strikes N. W. by compass (1355). It is bedded with rocks like 1353 and 1354.

All along the N. shore from the N. E. end of the lake to about the center of N. E. ¼ of sec. 31, 65-5, these tilted slates and quartzytes extend, having a high dip toward the N. E., and finally becoming vertical. The shore line runs across the strike, but not at a right angle. Hence in going west one passes on to lower and lower beds. At this place the Ogishke conglomerate (1356) appears on the shore, rising in a ridge about fifty feet high, at a few rods from the shore. On the beach it is disintegrated and hardly perceptible The dip of the beds of quartzyte and slate that are interbedded with it, is 88° N. E., and the strike N. W. *There is thus seen to be undeniable graduation from the Animike into the conglomerate.* This conglomerate makes also a small rock island near the shore. The greenstone hills still rise to the north of this. A little N. E. from the conglomerate are fine-grained beds which on the weathered surfaces appear like flint changed by weathering, but they are instead a very fine, siliceous, granular rock. There are different grades, about four feet of these flinty layers (1357). The strike of these beds from here would carry them, if continued, to the shores of Fox and Agamok lakes where they were described and illustrated by some figures in the report of last year (pp. 376-7-8).

Crossing the lake about south, to where the ninth "Correction line" (also the town line) intersects the shore, we found a gray feldspathic quartzyte in outcrop, in beds from four to ten inches thick, dipping about southeast at an angle of abont 40° (1358). This may be the Pewabic quartzyte, but contains much more feldspathic material than where it appears north of Flying Cloud lake. Further, it becomes converted into a biotitic gneiss (1359), in large part, similar to that seen on the Kawishiwi, and in that condition it acts like a matrix, rotting and crumbling and allowing round pieces of hard gray quartzyte to fall out and roll down to the beach. On the top of this bluff lies gabbro in place, but the contact is not visible.

On passing further along westward this rock shows some evidence of having been originally a conglomerate, i. e. that these gray "quartzyte" pieces are foreign pebbles. They hence show some kind of a non-conformity between this biotitic gneiss (or changed quartzyte) and the formation (presumably the Animike) from which they were derived. This, however, may be nothing more than the disturbed condition incident to the eruption of some of the gabbro sheets with which the period of the Pewabic quartzyte seems to have been marked.

At a point little further southwest the gabbro comes down the water, and forms the coast-line. On a vertical cliff is a conspicuous green coating (1360), evidently a weather-effect, from decay. The scale which coats the rock has the hardness of 4 to 5, and is at first white, or becomes white when thickly accumulated, although the exterior surface is continually pea-green. It does not effervesce in HCl. It may result from a change in the menaccanite of the gabbro.

About on the town line between 64-5 and 6, secs. 6 and 1, south shore of Gabemichigama lake, is a beautiful basaltic greenstone dike (1361). It is apparently not over ten feet wide, and on the side where the gabbro which it cuts has been carried away by the lake it shows the ends of the basaltic columns somewhat as represented by Norwood in his lake Superior report, handsomely piled up and fitted together. The gabbro here is apparently affected by near contact with the quartzyte, and is decaying and dissappearing, but the dike-rock is firm and fresh even to the very water.

The iron cliff on the south side of Gabemichigama lake rises about 40 feet. It consists of a muscovado-quartzose rock perfectly comparable to the beds seen at Chub lake, associated with the magnetited Pewabic quartzyte. It is filled with minerals derived from the changes effected by the gabbro overflow, as supposed. There are glittering broad surfaces, apparently of a pyroxenic mineral, which in its extentension embraces many small grains of quartz and of magnetite. Indeed, the upper part of the cliff looks much like the bottom part of the gabbro. It is all impregnated with magnetite, and the compass needle is useless. The sample obtained (1362) came from near the top of the cliff, but does not show the coarsely crystalline texture and the crumbling condition of most of the bluff toward the top. Near the bottom a recent slide has exposed some fresh regular beds of quartzyte (1364). When freshly broken these show an essentially granular, quartzose and magnetited composition, but also on some surfaces a fibrous, uniform crystalline mineral reflects a sheen of light that indicates a common matrix for all the grains. When partly decayed this matrix itself breaks up into grains, when the rock exhibits the muscovado-characters, especially if the silica and the magnetite fade out, and are replaced by some feldspathic ingredient. Mingled with the quartz grains are some of olivine. Indeed this rock makes, undoubtedly, the olivine rock, and affords the olivinitic ore which has been seen in many places near the northern border of the gabbro. The general dip, at this place is nearly east, and at the bottom. where it is distinct, in the bedded quartzyte (1364) it is 20°, but generally in the face of the crumbling cliff, and where it is heavily bedded and more coarsely crystalline in spots, it appears to be not more than ten degrees: much of this rock might be taken for rotten gabbro, or biotite gneiss.

A little N. E. of the narrows of Gabemichigama lake, on the south shore, a banded, rusty-coated, coarse, heavy quartzyte appears (1365). It has apparently olivine as well as magnetite, and is a part of the same beds as above described.

Just at the entrance of the narrows are beds of firm, quartzose muscovado rock (1366) embraced in the above quartzyte, dipping S.E, the former appearing in at least two thick beds. The Pewabic quartzyte here is rather quartzose, and resembles the iron beds seen at Chub lake, and on the trip north from Flying Cloud lake.

This quartzyte strikes across the lake at the narrows, even causes the narrows, and appears on the west side, while gabbro takes its place round the southern shores of the southwestern bay.

At the near head of the southwest bay, but on the west side, is a small outcrop of coarse conglomeritic quartzyte, allied apparently to the Ogishke conglomerate, but it is overlain by a rotting, biotitic muscovado form (of gabbro?), and I could not make out any dip. It contains isolated pieces of finer rock, not argillyte, but recalling in some way the argillyte distributed in the graywacke at Tower.

From a camp which we made on the west shore of Gabemichigama lake, just south and east of the high hill that rises from the lake shore, an ascent of this hill was made, and the rock was carefully examined at numerous places, and samples were taken at ten places (1367), intended to show the average character. At the shore south of the hill (in the southwest bay, already noted), is a coarse, though greenish, conglomerate or grit. The same rock is found near the foot of the hill and at intervals all the way to near the summit, but it becomes finer and finer, and cannot be distinguished in some cases from some of the finer beds of the Animike. The whole aspect of the hill in its form, the strike of the main rock outcrops, the confused mingling of structure and texture, is that of an eruptive rock, whether from deep source or not. The color is dark, and at first glance it might be taken for a greenstone eruptive. These eruptive features are more pronounced near the top. Still, it is of a light green color, and scarcely a sample can be obtained which does not show some free rounded grains of silica. The whole rock appears somewhat siliceous. Some of it is dark-blue, and fine-grained as argillyte. There are occasional rusty, or irony, patches, like the rusty patches seen in the Animike at Gunflint lake. There are siliceous seams of the same color as the body of the rock, but much harder and finer, which on the weathered surface give a ridged reticulation like that which was photographed at the west end of Kekekebic lake last year. Re-examining all the specimens, and comparing all the facts, I am convinced this hill is made up mainly of modified beds, perhaps of the Animike, but that they have been in almost a plastic slate, and probably toward the summit were mingled with a truly eruptive greenstone without free silica, and without traces of sedimentary structure and composition.

Ten samples, 1367, are intended to show the above mentioned sedimentary characters, taken from the southern slope in ascending.

Three samples, 1368, show the nature of the summit, being a more homogeneous, darker, medium-grained, green rock, without very evident free quartz.

The position of this ambiguous hill with respect to the strike of the Pewabic quartzyte, and its general character, while comparing perfectly with that seen north of Chub lake and north of Flying Cloud lake (1345), has some evident features that ally it with the Animike, and tend to confirm the suggestion, already made, that the rocks 1345 and 1335 are in the place of the greater part of the Animike slates and quartzytes, but have been modified either by deep-seated thermal agents, or by the action of the gabbro overflow, so as to constitute now almost a completely crystalline rock. * Still these rocks (1367 and 1345) differ, in that 1345 has a tendency toward a fine-grained dioryte. It will require more examination, chemical and microscopical, to determine the nature of these rocks more exactly, and it is only after such discriminations are made that some inference can be drawn as to their genesis.

Perhaps one of the most important points to be considered in connection with this hypothetical metamorphism of the Animike slates and quartzytes into the gray-green rock of this hill, and other hills further west, is the disappearance, otherwise, of the Animike strata in their course westward from Gunflint lake. It is true that the beds seen at Chub lake, associated with the Pewabic quartzyte, have an exact agreement with some of those seen at Gunflint lake, but they are insignificant in amount, the great mass of the formation seen at Chub lake being quartzose and quite different from the most of the Animike strata. The same is true of the section observed N. from Flying Cloud lake. In both places, on the supposition that the Pewabic quartzyte overlies the Animike, there is no Animike found under it unless it be this rock. Further, at a point still farther west, at the northeast extremity of Gabemichigama lake, where the Animike formation can be

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e, however, p. 95; on *Ogishke Muncie lake*.

recognized again, the strata are greatly broken, and lie in discordant and variant dip and strike. Here they can be seen, as already noted, interstratified with the Ogishke conglomerate; and in their passage toward the hills west of this lake they exhibit, about Fox and Agamok lakes, some remarkable instances of fracture and metamorphism. It remains yet to ascertain how much, if any, of the rock which here constitutes the "greenstone belt" can be referred unmistakably to a deep-seated eruptive origin. It should be noted, however, that in this statement is not included the greenstone which becomes micaceous and hornblendic, seen on the north side of Gunflint lake, and again west of that lake, which forms a terrane older than the Animike, and also older than the Kewatin, and is distinguished as the *Vermilion group*.

With intervals of non-exposure the foregoing rock (1367) extends along the N. W. shore of Gabemichigama lake as far as the portage to Agamok lake. From there to Ogishke Muncie lake is a wild mixture of graywacke, argillyte and flint, with patches of conglomerate. These are broken confusedly, dip in all directions and at all degrees of incline. It is in my opinion the Animike formation. The hill range that includes the hill last described, as well as the Twin Mts., crosses this route between Agamok and Fox lakes, and the only rock visible is this broken Animike sort.

OGISHKE MUNCIE LAKE.

But just before reaching the shore of Ogishke Muncie lake, not far east of the portage trail, a fissile, schistose light green rock is found. This embraces the marble, so-called (746) discovered in 1879, and again further east last year (1069), and belongs probably to the Kewatin series of rocks.

Making a further examination of this marble at the point near the N. E. end of Ogihske Muncie lake where was obtained last year rock 1069 (fifteenth report p. 371), I find the marble (1369) including the other schist mixed with it, is about 25 feet wide, and that it strikes N. 38° E. The argillitic slate (1370), lying next west, along the lake (No. 6, of the diagram on p. 371), and the conglomerate associated with it, strike in the same direction. The slate is vertical, and is due to the thin (sedimentary ?) lamination.

The marble is impure, apparently siliceous, and seems to blend with the chloritic slate or schist which is included with it, but many of
sty weathered surface are angular and
bedded structure, nor any uniform

structure except a coarse disintegrating schistosity which coincides with, and causes, the strike of the outcrop.

The marble, so-called, is in some manner allied to the rock in the hill toward the S. E., because small amounts (1371) of it are disseminated in it; but these do not extend far from the main marble ridge. There is a narrow valley between the marble ridge and the more elevated shore, in which no rock is exposed.

The shore is composed of the rock 1068 and 1372. It appears like a massive doleryte in some places and presents basaltic forms; but it embraces numerous evidences of sedimentary structure and origin for the pebbles, quartz grains and fragmental masses of strata embraced in it. It is massive, basaltically and otherwise jointed, green, roughened on the weathered surface by the projecting siliceous and feldspathic grains, and in some places has a lighter green color. There are in it small contorted areas of cherty argillyte (1373) which, weathering much lighter (a pea-green, or more nearly white), appear like siliceous veinings, but really exhibit the banding of weathered, cherty or flinty argillyte. These are shaped about rounded areas as if of boulders, but the included boulders (?) are the same as the main rock, and comprise elsewhere, the whole of it, but their forms are not evident.

In other places this conglomerate—be it igneous or changed sedimentary, that's the problem—shows patches of what appears bedded graywacke. One such is 14 inches wide and extends 4½ feet N. 35° W.; but it has a feather-edge caused by the successive branching away and disappearance in the matrix of the conglomerate, of different layers of itself, some of them weathering lighter colored, and all of them having a wavy structure.

Traveling southeastward (this is in N. ½ of sec. 24, 65-6) about a quarter of a mile away from the lake shore, we find the same greenish, massive but indistinctly conglomeritic rock continues. It disintegrates, on decay, schistosely, with a siliceous and chloritic matrix. Near the place where we turned back is an area of graywacke and slate, embraced in it. This runs diagonally across its own strike about 30 feet, but it changes its own strike in that distance from N. 10° W. to N. 45° W. This is an included mass and transported from its native place by some agency, though perhaps not far. Indeed it may be only a part of a general sedimentary formation which, becoming plastic, then compacted again, allowed this large fragment to keep nearly intact its stratiform arrangement. It is about ten feet across, and on each side of it, in the enclosing rock no structure can be seen, —simply the formless though sometimes boulder-filled green rock.

On searching further this stratiform belt, with windings and uncorformities within itself, extends northwestwardly about ten rods, and fades out. Along its westerly edge it has, in some cases at least, an abrupt and non-conformable transition to the green rock, and in other cases the green rock also exhibits a faint lining of a remnant of stratification contiguous to the line of junction, but the directions of the two are apt to disagree. Taken as a whole this banded portion turns gradually from N. 10° W. to N. 50° W. It makes this grand swing, but in some places it shows abrupt changes and discordances.

In the banded gray-wacken argillitic parts some of the pebbles seem to have a hardened shelly exterior, and sometimes two hardened cases (1374) as if concretionary.

North from this place, in the narrow spot in sec. 13, between Ogishke Muncie lake and the lake south of Townline lake, strikes a Kewatin-like rock (1375) i. e. a schistosely disintegrating light-green, or sometimes slightly reddish, apparently fragmental rock containing much free quartz, a phase of the conglomerate. It is mingled with some coarse conglomerate, and patches of argillyte and occasionally seems to have the character of the silky poroditic quartz-free rock of Stuntz island at Vermilion lake.

1376. Greenish argillyte from the conglomerate.

1377. Piece of a pebble from the conglomeritic part.

1378. Rusty carbonate appears in patches in this rock.

In general, the green rock lying adjoining the so-called marble, described above, embracing conglomeritic and brecciated parts; also the rocks extending further north (1375—1378), have their counterparts in the region of Tower, as described in the last report, and cannot consistently be considered other than parts of the same formation (Kewatin). All the structural features are also seen about Tower, and eastward from there toward Fall lake. On the other hand, this green, eruptive-looking conglomerate has such a close geographic relationship, and so strong a lithologic resemblance to the pebbly conglomerate of Twin Mt. (1077), as well as to the green rock seen in the hill west of Gabemichigama lake (1367), and to that seen about the shores of Frog Rock and Saddle Bags lakes, that they seem to be necessarily of the same terrane. They cannot, therefore, be modified portions of the Animike, because that has been shown to lie unconformably on the Kewatin. This eruptive-looking conglomerate cannot, hence, be the same as the conglomerate seen to be interbedded with Animike argillytes and quartzytes at the N. E. end of Gabemichigama lake. There seem to be, therefore, two conglomerates about Ogishke Muncie lake, viz:

1st. This old eruptive-looking, massive, schistosely weathering and decaying Ogishke conglomerate which appertains to the Kewatin, and extends from Stuntz island, in Vermilion lake, past Ely (where it was recently examined at the Iron mines) to Twin Mt. and Frog Rock lake.

2nd. The Ogishke conglomerate, of later date, which is interstratified with Animike argillytes and quartzytes, much fresher in aspect, very siliceous, evidently derived largely from the disintegration of the other, unconformable on the other, but involved with it in profound fracturing and metamorphism.

Accordingly it will not be allowable to suppose that the Animike strata, in their passage westward from Gunflint lake become converted into the rock on which the Pewabic quartzyte lies at Chub lake, and northward from Flying Cloud lake; but those ambiguous greenstone rocks (1335, 1345 and 1367) should be placed in the eastward prolongation of the similarly ambiguous greenstone seen at Tower and at Stuntz island, and perhaps that which causes the falls of Kawasachong.

SADDLE BAGS LAKE AND FROG ROCK LAKE.

The former of these names was applied to a small lake that lies south of Townline lake, between Ogishke Muncie and Frog Rock lakes, suggested by its shape. This lake was approached by a portage (without trail) from Ogishke Muncie lake, and about its shores was found a form of greenstone in which are seen occasional traces of sedimentation, appertaining, probably, to fragments, large and small, which are embraced in a once plastic matrix, in a manner similar to that evinced by the rocks 1372, 1379 and 1380.

A similar rock environs Frog Rock lake, but in some places it approaches a true greenstone (1381). Going south from Frog Rock lake to the center of sec. 19, 65-5, we crossed a wooded country with occasional low ridges of greenstone and gritty greenstone, represented by 1382. At the farthest point reached the rock 1383 appears, but it is associated with 1384 which is finer-grained, in part, and conglomeritic in part, sometimes banded, and evidently a fragmental phase in the eruptive-looking greenstone—conglomerate.

NOTES MADE BETWEEN OGISHKE MUNCIE LAKE AND KEKEKEBIC LAKE.

At the west end of Ogishke Muncie lake, on the southerly portage to Dike lake, is a dark, slaty argillyte (1385) on which are fine ripple marks. These become visible on separating the fine laminæ of the slate. This slate resembles that seen in the Animike. On the edges, when freshly broken, it is finely banded with sedimentary colors. The ripple marks are well formed and preserved.

From this point *an ascent was made, by Mr. F. N. Stacy, of East Twin Mt.*, and he reported substantially the following results. The position of the mountain was ascertained from magnetic observations, on a common compass needle, as follows:

The north side of Little Saganaga lake is E. 10° S. (mag.).

Camper's island is N. 20° E. (mag.).

Lake Saganaga (a broad expanse of water) is N. 15° E. (mag.).

The mountain which lies at the west side of lake Gabemichigama (rocks 1367 and 1368), which is near the center of sec. 1, 64-6, is about due east (mag.).

These directions place East Twin mountain not far from the center of sec. 4, 64-6, nearly a mile further south, and half a mile further west than was represented on the geological map accompanying the last report.

The summit of the mountain is made of the rock 1386, a coarse hornblendic greenstone, resembling rock 759 (10th report, p. 97), but which on deeper fracture appears to be a titaniferous gabbro.

Near the top, but on the body of the hill, on the north side, was seen a finer greenstone (1387). But further down (still on the north side), near the bottom of the hill, it is a coarser rock (1388) of the same kind as 1387, but not so gabbro-like as 1386; but at the bottom of the hill are found both coarse and fine (1389), the coarse being identical with 1386.

According to the observation made by Mr. Stacy this hill is set off abruptly, both topographically and lithologically from the following by a ravine, or series of irregular, branching valleys. The hill rises about 350 feet above this ravine. The rocks that constitute the lower hills on the north side of this ravine are in the main an ambiguous greenstone (1390), and seem to be closely associated, perhaps blended into, the prevailing sedimentary rocks that are seen about the S. W. shores of Ogishke Muncie lake. These sedimentaries consist of cherty slate, conglomerate, &c. This lower hill-range hides the Twin mountains from sight, from Ogishke Muncie lake, except at the N. E.

end of the lake, and seems to be a connecting line between the Twin mountains and the hills immediately west of Gabemichigama lake. It lies not far north of the Twin peaks. Indeed, Mr. Stacy represents that the peaks are simply higher parts of a general hill-range, cut off by ravines from the rest of the range, and that in general, the fragmental rocks cease before reaching the ravine mentioned.

Rocks 1391, 1392, 1893, 1394 and 1395 represent the broken sedimentary rocks intervening between the peaks and Ogishke Muncie lake. No. 1393 represents several small hills, or hill ranges, a gritty greenstone, a modified sedimentary. No. 1394 is chalcedonic silica, and samples closely related, all enclosed in and banded together in 1393. These are in three small ridges, successively, but the samples are all from the same ridge. The chalcedonic silica seems to indicate the horizon of the Kewatin, and the iron ore here associated with it, although magnetite, does not preclude the parallelizing of this nearly with the horizon at Tower. No. 1395, which is a widely disseminated rock, is a greenish conglomeritic one, the same as seen in many places about Ogishke Muncie lake, a part also of the Kewatin, as already mentioned. It is filled with fragmental material, but takes the forms and basaltic habit of an eruptive. It seems to be made up largely, in some places, of broken masses of older strata, as well as of individual fragmental grains, the whole compacted together by a prevailing greenish, doleritic matrix.

The hill directly east of Alpha lake is composed of hardened graywacke and slate, having a balsaltic jointage (1396). It is cut near the lake by a green dike-like belt (1397) but this may be a part of the plastic sedimentaries, as it is not a persistent direction. Macrospically it appears like a diabase, sparsely porphyritic.

KEKEKEBIC LAKE.

The gray porphyry (1094) at the S. W. cor. of sec. 29, 65-6, rises about 100 feet above the lake, and composes the whole peninsula, making a knob by itself. It is very siliceous (1398). It is massive, or coarsely jointed. The feldspar crystals are not always perfect in form, but approximate a true crystalline shape. They seem to be of orthoclase. They weather red. The long exposed (or at least the burnt) surface of the whole rock becomes reddish, but the surface scales off by fire and keeps a fresh gray color exposed. There is in some places a prevailing direction—that of the general strike—seen in the longer axes of the crystals. They are also apt to stand vertical, edgewise, in the same direction. In the rock are boulder-forms These are most frequently of greenstone, and then they are not porphyritic, but sometimes they are of some rock which weathers a pinkish red color. They are also of a siliceous gray rock resembling the matrix of the porphyry, but finer-grained, and also of other light-weathering kinds. But in the main this is a homogeneous rock. These boulder-forms are by no means a common occurence, at least at this place. Yet in other places there is a various distribution apparent in the crystals. They are either more conspicuous and more numerous, or else less frequent, in rounded spots; or they stand out at different angles, as if they had been dependent on the varying nature, position, structure or grain of the enclosing rock. This distribution and confused arrangement are so combined as to bring out to view indistinct outlines of former included boulders. From this I conclude that the whole rock is a modified condition of the sedimentaries here prevalent, and that it indicates what would become of the whole formation (conglomerate, graywacke, slate, chert, &c.) if under similar conditions the rearrangement and recrystallization had been carried to completion—a syenite or a granite, at least an acidic rock. Here there is no basic surplus to give the rock a doleritic aspect. Where this has been the case the singular, "ambiguous greenstone" has apparently been the product, a kind of fragmental basalt.

This porphyry knob lies between two hardened graywacke and slate ridges, that on the north being Mallmann's peak and its eastern extension, and that on the south being on the opposite side of the lake (here quite narrow). It is just east of the great dike that strikes across the lake here.

On the south side, immediately opposite this knob, but a little further west, this porphyry is found again. The specimen obtained (1400) is from close proximity to the greenstone dike, but the whole rock here weathers red distinctly, and also has crystalline hornblende. It seems as if the fracture which gave exit to the greenstone may also have had some agency either in the protrusion or in the production of the porphyry.

The dike which crosses Kekekebic lake (1401) * forms two islands. The rock (1402) on the west of the dike, on the southerly island, while apparently a part of the porphyry already mentioned, is also as plainly a part of the red weathering gneiss seen farther west in the islands of this lake. The porphyry on the east side, at this place, is not visible.

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* Fifteenth report, pp. 368 and 158.

This gray gneiss (1403) appears on the main land a little farther west; and while weathering reddish, showing its identity with the rock of the islands, it also takes the characters of the porphyry (1400), including the boulder forms. These forms are here everywhere visible, whether the rock be gneiss or porphyry, or porphyritic gneiss.

As a gneiss it shows a schistose bedding 2-4 inches thick which, in one place at least, dips into the lake, northwardly; but this bedding is not of sedimentary origin. It is a layered manner of disintegrating. Further west it dips south, in each case about 25°.

Ascending the hill, half a mile from the lake, near the center of sec. 31, 65-6, we pass over first a low ridge of this gray red-weathering gneiss, showing boulders included, the visible ones being mostly some form of greenstone, and reach the summit of a hardened graywacke and slate, gritty, greenstone ridge, represented by rock 1404. Further south a higher hill rises, which was not visited. If the succession observed in the rocks of the Twin peaks be preserved here, this upper ridge would be likely to be of true eruptive greenstone.

The point on the N. W. ¼, S. W. ¼ sec. 31, 65-6, is composed of two rocks. One is 1405, a quartzose rock with a fine porphyritic tendency, gray inside, weathering reddish-gray and disintegrating with a coarse, schistose decomposition like the gneiss. This is a phase of the conglomerate which graduates either way, to the real porphyry or to the gneiss. The other rock is a conglomerate (1406) with a green matrix. It acquires outwardly a schisto-fibrous structure running E. 20° S., and in disintegration seems to become finely micaceous. A little further west, on the point, this rises high, and is basaltic, very pebbly, and holds many jasper pieces. On the extremity of this point which is at the narrows of the lake, is a gray porphyry (1407).

Stacy island, the easterly of the two, is made up of the conglomerate of the main land opposite, at the bottom, and a hardened graywacke, etc., overlying. But on the north side, near the water, the rock has a bedded, acquired, structure similar to that seen in the gneiss and porphyry; but the whole is greenish and not gray.

The island west of Stacy island is composed of the same gray porphyritic gneiss (1408). This has orthoclase, hornblende and (black?) mica, and an abundant quartzose base remaining.

The latter island just west of the narrows, near the north shore of the lake, is made up of chloritic schist. The sample (1409) came from near the water, south side, while that numbered 1410 came from the top of the same island. There are 15 feet of bedded (sedimentary) north-dipping chloritic schist of this kind. The schistose fiber runs (on the top) N. 45° E., and the dip is N. 30° W., about 25°. This all readily disintegrates, and as it is found extensively about the N. and W. shores of this lake it probably occupies largely the lake bottom. It seems at least to occupy it at the narrows. This soft rock extends westward from here, so as to enter the shore, and probably is the same as the chlorite schist seen adjacent to a knob of porphyry last year (15th report, pp. 367, 154). Here this green rock has a distinct sedimentary dip, as given, which precludes its being of eruptive origin. This bedded structure is visible, when freshly eroded. on the south side, but is not on weathered surfaces. It is somewhat more siliceous in some beds (1411) near the middle of the south cliff. The sample shows the sedimentary lining. It holds, near the bottom, small rounded nodules (1412) of rock like itself, somewhat simulating "boulders by disintegration," as well as some short lenticular sheets of finer rock not very different from itself (1413) the last being a part of the bedded arrangement. At the extreme S. W. corner of the island these beds are conglomeritic at the low-water line.

The smaller island, north of the last, has a similar rock, but is in places abundantly porphyritic, and dips N. 15° E. There is another small rock island just E. or N. E. of the first, in which the same rock appears, but dips southerly at an angle of about 80°.

Considerable search was made for some outcrop of the porphyry, or gneiss, which would show its exact stratigraphic position with reference to some other member of the series; but in nearly every instance the contact was hid by forest, or by drift and debris; until on coasting again westward, near the E. and W. town line, along the south side of sec. 35, 65-7, at the prominent round point of land projecting into the lake, a low bluff of the porphyry was noticed which was undermined by the more rapid disintegration of some lower and softer rock. Numerous large pieces of greenish chloritic rock, resembling the green schist seen in the small islands near the north shore in the narrows, lay here on the beach, disrupted by frost. It required but little search to find that their native place was just under the overhanging cliff of porphyry, at the water-level. Rock 1414 represents different forms of the porphyry in this little cliff, which rises about ten feet. Rock 1415 shows the underlying greenish (biotitic?) rock which rapidly wears away. This greenish rock also spreads upward irregularly, in a few patches of irregular shape (1416) in the porphyry, (the sample

an porphyry).

les into the gneiss of the islands and into the red rock seen last year along the S. W. shore of lake Kekekebic. are both conglomeritic.

This porphyry lies on the green biotitic schist (at least in one p which is so common about the lake, and which itself is bedded, mental, and becomes a conglomerate that readily disintegrates.

This porphyry, and hence this fine, gray, red-weathering gneis of more recent date than the green schist. If the porphyry hol position as overflow through the action of eruption, it still may condition of the conglomerate seen about Ogishke Muncie lake w underlies the Animike.

Here seems to be an instance of a gneiss which is not Lauren but which has been erupted through the Kewatin, and is perh result of the modification of a Kewatin conglomerate. It is in line of strike from the coarsely crystalline syenite area further s west, which appears on the east side of White Iron lake, and w rises still further southwest and constitutes what is called, in reports, the Giant's range, but on which the Duluth and Iron R railroad has a station named "Messaba Heights." This is an isol abrupt, granite or syenite range, and evidently is of eruptive origi the same sense that this prophyry at Kekekebic lake is; an acid e tive, later than the Laurentian, originally from some of the strat the earth's super-crust, and not from a deep source. It hence ma on any formation older than the date of the eruption. The read referred, in this connection, to an other part of the report where s observations at the Aurora mine, on the Gogebic iron range, stated, in which it is also shown that a conglomeritic syenite lie some stratified sedimentary beds, probably the Animike. He is referred to the fifteenth report, pp. 349 and 355, where some other and general considerations bearing on this origin of granites wi found.

Rock 1416, a reddish porphyritic gneiss, the same as 1105, show intergrading of the gneissic, the porphyritic and the conglome characters in the same rock.

This has been called *gneiss* this year and last, but it needs a of qualification. It has not the real gneissic structure, or foli supposed to be due to original sedimentary bedding. It has quired a sheeted structure, but in general it is massive rock, sho variations due to the original conglomeritic state of its material already described. Where it passes into the porphyry it is more pact and more firm than when it is not porphyritic.*

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*The former state of this rock has been named *porphyrel* by my brother in the fifteenth re 159.

Shingwak island, (north of Animike island) is made of the red-weathering, gneissic rock (1417), but it is clouded with the variations due to the original conglomeritic nature.

Sometimes the red crystals run into a greenish biotitic rock (1418), which is associated with the red rock, the changes from one to the other being, here, in perpendicular planes.

The very small island directly south of Shingwak island is not red weathering, but the rock is fine-grained, greenish-gray, hardened graywacke, (1419)—with fine mica scales sparsely disseminated. Its sedimentary bedding planes are distinctly preserved.

At the west end of Animike island there is a conspicuous dip of the "acquired" bedding toward the north. While the rock here is essentially all alike, yet some of it does not take a red color in weathering (1420). I could not discern any definite order in this difference of color. Still the gray color seems to prevail in the middle beds, and the red at the N. and S. parts of the bluff. The colors are not distinctly separated. The acquired bedding, in all these islands seems to dip toward the north.

At the S. W. end of lake Kekekebic the rock is greenish and micaceous (1421), but it has all the characters of the chlorite-schist-conglomerate (1409-13) seen in the little islands near the north shore at the narrows, except that it does not here show such evident stratification. The reason seems to be that it dips away from the observer, and in general away from the lake along the west shore. It appears much like a crystalline rock, but it is of fragmental origin. At the water-level are purgatories that are wought by the water in the softer layers, roofed over by some of the former. It has harder seams and lumps that stand out on the surface.

There are two small islands south of the point in the W. part of sec. 3, 64-7, one of which consists of the same red rock as the islands further east. The other consists partly of red rock and partly of green and red (1422). They are all mingled, even the red crystals appearing sparingly in the green

The tip of the point consists of red rock (gneiss) but at the base, on the south side, are Animike slates, fine, black, closely jointed and hard, like the black slates, seen on Kekekebic last year, and being identical, apparently with the Animike slates at Gunflint lake. These slates dip east about 75 degrees, and their north-south strike continues so far as to run along the shore of the square land projection which is just north of the small point, dipping still easterly and exhibiting a high bold lakeward front, characteristic of the hardened slate group on this lake. If they continue far enough, with this dip, under the water, they must run below the reddish rock of the islands. In the same way if the dip of the gneiss in the islands (the coarse, acquired bedding) continued under the water, its western portions at least would pass below these slates. But it is certain that the dip and strike of the slates and greenish conglomerate are inconstant. This is shown by numerous observations already recorded, and it is hence probable, that although locally the gneiss (or porphyry) may overlie the exhibits through the accidents of local fusion or protrusion, the formation in general to which the red rock belongs is older than the schist and slate, and would be found lying below it when not so disturbed.

On the next, square, point the dip of the slates is N.E. at 45° angle, changing soon to 35°. But on the north side of the point, near the town line, but not at the head of the bay, the dip is again S.E.

At the head of the bay, west end of Kekekebic lake, on the town line, the green schist-conglomerate (1423) appears again, same as seen in the islands at the narrows. At the water-line the weathered surface is roughened by numerous small knot-like projections (1424). Some of them take the form of ridges. These projections make the rock look like a conglomerate. The ridges are hardened seams, and run in all directions. The general structure is vertical and in the same direction as in the islands. The rock is green. It easily wears away, i. e. more easily than the slates and greenish graywackes; yet it produces sharp, short points and islands in the teeth of the waves. At this place no certain sedimentary structure is observable, but on the north side of the little sharp point a sedimentary lining is visible in rock 1423, showing a dip E. 10° S. This structure is like that seen in the islands at the narrows.

On the shore north of this bay, and eastward, the same rock continues, and dips S.E., until it is cut by a dike (1425) on the north side of the next bay. South of this dike the green schist appears at the head of the bay, and has coarse pebbles.

Crossing this bay and coming to the point which projects S.W. toward its counterpart on the opposite side of the bay, the slates and chloritic graywackes appear again, thus *showing that in general the green pebbly beds lie below these slates.* Yet on this point there is a local dip in the slates toward the green schist beds; but the dip varies, sometimes being vertical.

Next, further east, in S. W. ¼, sec. 34, 64-7, on the shore of Kekekebic lake, near the head of the broad shallow bay, is an important variation. The graywackes vary to the green beds, but are pebbly conglomeritic. They also show a disappointed struggling ambition to become porphyritic. The color is not gray, nor green, but gray-green, and there are apparently a few fine crystals of hornblende in some parts of it. The reddish weathering siliceous portions sometimes are mingled distinctly with the softer greenish or grayish portions, the latter becoming micaceous on decay (1426). It appears as if the porphyry, the reddish gneiss, as well as the hornblende porphyry of Mallmann's peak (No. 751), were intimately associated here in embryo, in one and the same rock with the green schist conglomerate, and that by differentiation they could all be brought out, and belong genetically to the same formation. Still this commingling of characters is probably only local, such as is incident to the contact of any two formations. When it is remembered also that the porphyry and the gray gneissic rock seem to have been plastic *since the deposition of the green schist conglomerate*, and has been protruded through and overlies it, it is not only reasonable to expect that the schist would embrace materials like the original sediments of the porphyry, but also that the porphyry should enclose parts of the schist. In a common softening and metamorphism the two rocks would thus come to show approximations in mineral characters toward each other at the points of contact.

Thence to the portage going north the same green, finely conglomeritic rock continues, as noted last year.

Before leaving Kekekebic lake it would be well to group some of the recorded facts into general statements, and to give some of the inferences to which they seem to lead. These inferences are provisional, and are based on the field observations, extended now over this lake twice, but they may have to be modified when the rock samples collected have been subjected to thin-sectioning and microscopic inspection.

There are, in the main, but three formations that are to be considered.

1. The changed conglomerate, or porphyrel.
2. The green chlorite-schist-conglomerate.
3. The black slate—which resembles the Animike.

The porphyrel is plainly an extension of the same part of the Ogishke conglomerate westward. The change which converted that conglomerate into this acid eruptive rock was subsequent to the deposition of the Animike rocks and the disturbance that accompanied it involved the slates and other parts of the Animike. It was perhaps cotemporary with the formation of the last of the basic dikes. In general the conglomerate was not much moved out of its place, but was metamorphosed *in situ*, in some cases retaining some evidences of its mechanical sedimentary manner of deposition.* In others it was protruded in bosses that now rise boldly above the general level, and in still others was caused to lie upon some parts of the green schists in the manner of an overflow or laccolitic eruptive.

The green schist, which belongs apparently to a date about the same as the Kewatin portion of the Ogishke conglomerate, or is its immediate successor and conformable upon it where the contact is normal is still markedly different from it. It is apparently formed of basic erupted materials in a fragmental condition. It received its stratified arrangement through the agency of water. Volcanic vents in the immediate vicinity must have given origin to this vast supply of basic materials. It is to be considered, at present, a part of the Kewatin, because it is very likely the same as the "ambiguous greenstone" on the north flanks of Twin mountain, and in the section seen between Flying Cloud and Bingoshick lakes—and that has been excluded from the Animike (see under *Ogishke Muncie lake*, p. 98).

The Animike slates, which are associated with this green-schist-conglomerate in the N. W. part of the lake seem to have been the conformable successor to the green schist so far as continued aqueous deposition was able to make conformable succession. But it is very likely that this succession would not be found conformable in the vicinity of the old volcanic vents. There was a great basic eruption that separated the Animike from the Kewatin. That is evinced not only by the actuality of this fragmental basic rock, but by the existence of mountains of truly eruptive greenstone which show the probable sources of the fragmental debris. These two greenstones are found to lie, in every case, below the Animike, when they are present; at least they intervene between the general strike of the Animike and that of the Kewatin, with the Animike dipping away from them. The fragmental sedimentary "greenstone" probably graduates upward into the Animike slates, forming their basal conglomeritic portions wherever there was no break in the sedimentation. That part of this "ambiguous greenstone" which consists of breccia, or contains masses of contorted strata, as described at Ogishke Muncie lake, must have been formed in nearer proximity to the volcanic vents, where the succession of sedimentation was interrupted by upheaval, fracture and overflow.

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* Compare the 15th report, p. 353.

PSEUDO-MESSER LAKE AND WESTWARD TO TOWER.

In making the portages from Kekekebic lake toward Knife lake, the green fragmental schist, sometimes fine and sometimes pebbly, occasionally twisted and deprived of evident sedimentary structure, continues to Spoon lake. On the north side of Spoon lake, the same formation continues, but it is not green and soft—i. e. is not so green. It is rather grayish, and more firm, and mashed together so that the bedding planes appear occasionally as linings. The outward surface is rough to the touch with siliceous grains and seams, and the whole rock seems more siliceous. It is like some brecciated portions of the Animike seen along the international boundary line east of Gunflint lake. In this condition it looks as if a little more metamorphism would produce the red fine-grained gneiss.

The rock forming the point, N. E. cor. sec. 28, 65-7, in an area of Knife lake (1428), is a dark siliceous slate. But the interesting point in this rock is its compacted condition and incipient porphyrization, as well as the slightly pinkish tint which it acquires on weathered surfaces. This is not always dark within, but is grayish to black. The sample obtained last year a little further south, nearer the portage landing, was finer and black within.

We went to Pseudo-Messer lake by a route which crosses a part of Hunter's island. This is a much used trail, indeed is said to be the main route. It has long been used. I do not know why the boundary was established, on our maps, on the southern route where more portaging is necessary to reach Basswood lake. Was it because the U. S. township surveyors surveyed only to that line? If so it seems as if the United States has good claim to land, up to this old route, which seems to conform to the terms of the Webster-Ashburton treaty.

At the commencement of the first portage on Hunter's island the black siliceous slates seen last year (and again this) at the point where Knife lake is first reached from Kekekebic lake, appear, dipping southerly at an angle of 88 degrees, more or less; and at the summit of the divide the rock 1429 can be seen, which is about the same rock as at the south end of the portage, somewhat lighter colored. Slaty cleavage here runs E. 12° N. by compass, but the sedimentary dip is obscure. The slaty cleavage dips at a right angle with the direction of its strike, and the only symptom of sedimentary dip that can be found indicates a southerly direction, amounting to 88 degrees.

A little below the summit, and on the north slope, rather nearer the lake than the summit, is a dark gabbro-like dioryte (?), No. 1430. No contac with the other rock is visible, but it probably lies on it.

It forms a little ridge running S. SW., but slate recurs again just below, and continues to the lake.

The next portage to Pseudo-Messer lake is a short one, and at the west end No. 1431 appears. It is a light-green slate, rather firm, but showing a tendency to sericitic films between the laminæ. It has considerable free quartz in macroscopic grains. It resembles slate seen in the Kewatin about Long and Vermilion lakes.

The point in Pseudo-Messer lake that lies north from the portage landing, on the east side, (as extended, the U. S. survey lines would make it, on my plat, N.E ¼ sec. 19), consists of a slighty reddish-weathering, pyritiferous, fine-grained quartzyte, or gritty felsyte, firm and sharp in fracture, having no visible bedding, but looking like a changed (and now eruptive) rock (1432).

Directly across Pseudo-Messer lake from the portage landing occurs rock 1433. It is on two islands in a bay. It is a light-green schist, siliceous with chalcedonic silica, identical with some that had been described at Tower in connection with the iron-bearing rocks. This identity is further indicated by the existence here of small hematitic streaks, and jaspilyte, varying from white to red (1434 and 1435) which occurs in lumps, and in perpendicular lenticular sheets in 1433, in the same manner as at Tower This green rock is soft, schistose in the direction E. 20° N. and holds "chalcedonic" silica in nodules, also one narrow belt of jaspilitic, hematitic quartzyte about two and a half feet wide. Small pebbles of 1434, as small as a pin-head are disseminated in 1433. There is a siliceous framework also in 1433, apparently pervading it, that forms a roughness on the weathered surface, (compare the fifteenth annual report p. 229.)

It is very evident from the few observations that were made on Hunter's island, that the iron range of Vermilion lake extends across the Boundary waters and enters the British territory on the island.

Through Sucker and Carp lakes are only seen exposures of argillitic slates, graywackes and sericitic schists.

From Prairie portage to Opin Is., in Basswood lake, sec. 10, 64-10, the rock has a very uniform character. It is syenite varying to granite. It is split into sheets varying from one inch to six inches, usually about three inches, which are apt to dip north or south, but sometimes are nearly level. In addition to this bedding it has a gneissic structure, thus differing from the red, fine syenite of Kekekebic lake. It has occasionally belts of dark, quartzose, non-crystalline, or cryptocrystalline rock that show distinctly a lining due to sedimentation. These run short distances. It also holds patches and lenticular masses of granular hornblende, which is shown on the sample (1436) collected.

At the S. E. end of the portage, in S. E. ¼ sec. 6, 64-10, which leads from one part of Basswood lake to another, is a rock (1438) which seems to be simply a hardened graywacke, appearing now like a quartzose gray syenite-gneiss, with some chlorite that gives it color specks. At the N.W. end of this portage the landing is on mica schist, interlaminated with rock like 1438.

The bluff on the right bank, just below Pipestone falls, rises about 18 ft. direct from the water. It embraces three rocks, 1439, 1440 and 1441. No 1439 seems to be a dark hornblendic greenstone. It occurs on the face of the bluff, all about, and seems to graduate into rock 1440 There can be found no direct transition, nor can it be stated what the nature of the change is without microscopic examination, as the latter rock is fine grained, and seems to prevail over all the others. It seems to belong, however, with the mica schists, but is very firm and shows mica very sparingly. Rock 1441 is light-colored, somewhat reddish, coarsely granular chlorite syenite, or granulyte. This cuts both of the above rocks, running in seams and veins about five inches wide, nearly horizontal along the bluff. It also occurs in irregular bosses in the face of the bluff, alongside of which the rock 1439 stands in a vertical plane of contact.

Just above the rapids, where was obtained in 1878 rock numbered 349 from a low bluff on the right bank, there is now no rock exposed, the drift having concealed it; but large pieces that lie about are from a greenish schist, and are represented by 1442. No. 349 is styled peridotyte by Dr. Wadsworth, of the variety serpentine.

A very similar schist (1443), but more shining, lighter green, "talcose" or "sericitic," is found in abundant outcrop at the west end of the portage from Newton lake to Fall lake. It strikes toward the upper end of the rapids, at the upper landing, and apparently causes them. Its structure is about vertical, lenticular-wedged schistose, making, when weathered, a soft fissile schist. Compare 1109.

At the Cooper claim, near the head of the portage from Fall lake to Garden lake, a late stripping east and west reveals a run of jaspilyte which is six or eight rods across, at least, reaching from the west portage trail to near the river. It is more or less hematitic. At the west end of the stripping the jaspilyte is replaced by the greenstone of the region (999 and 1444).

At the place called "Silver City," north end of White Iron lake, the quartzyte containing the iron dips, on the north side of the hill, 74°N., 30°W. It is gray and similar to the Chub lake quartzyte (1445). It reverses the needle. It contains thin, irregular, green laminæ in which magnetite seems to gather most freely, but the ore is also scattered in fine rhombohedra in the quartzyte itself. The rock is certainly sedimentary in the direction stated, and thin slaty seams appear on the north side, due to that structure.

A little further west the rock dips more westerly, and the structure actually swings round so as to have an apparent dip S. W., i. e., toward White Iron lake. It is sometimes micaceous, i. e., its cleaved laminæ glitter with fine silvery scales which may be chloritic rather than micaceous, and result from a change of the green schistose substance that is interleaved with the quartz. Taken altogether, the formation is quartzyte, some of it being gray, granular, hard silica, and some of it very fine-grained and schistose. In the latter case it is darker colored, the coloring element being apparently a fine acicular mineral which lies with its longer axis parallel with the grain of the schist, and may be tremolite. Eleven samples collected (1146) show different variations and the associations of the ore.

The statigraphic position of this rock, and its geographic relations, seem to conspire to ally it with the *Vermilion series*, i. e. the mica-hornblendic rocks that are associated with the granites of the north side of Vermilion lake and north of Long lake. But the general direction of strike, from the Animike ores west of Gunflint lake and its mineral composition would allow of its being a part of the Pewabic quartzyte. It lies, however, on the other side of the Giant's range of granite from the Animike ores at Gunflint, and its age is probably that of the mica-schist. It is the only known iron-ore locality in the rocks of that age.

But a short distance below this mica-hornblende-quartzyte knob, but on the opposite (N.) side of the river, appears rock 1447 in a low outcrop. This is a fine, fibrous, greenish rock which at first glance appears like a diabase, but is in reality an extension of the tremolitic (?) quartzyte formation just described.

On the north shore of Mud lake, near the west end of the lake, but about half a mile from the lake (N. W. ¼, sec. 4, 62-14) some recent drilling has been prosecuted with a diamond drill. The rock here is the "ambiguous greenstone," with chalcedonic silica, which accompanies the ore at Tower. Nothing but this green rock (1448) can be seen at the location, and no rock at all along the road from the creek. Some samples of the drill-core which lie about, consist of the same. The place is deserted at present. No iron outcrop could be found. Samples said to have come from the place, obtained since from Mr. J. C. Clark, have been analyzed by Prof. Dodge with the following results:

	No. 1.	No. 2.
Silica	21.70	5.26
Lime	0.21	0.15
Phosphorus	0.17	0.18
Magnesia	traces	traces.
Manganese	none	none.
Titanium	none	none.
Sulphur	none	none.
Mag. oxide	77.62	92 76
	99.70	98 35
Metallic iron	56.21	67.11

At the Stone mine, at Tower, the old excavation is being filled, covering the "dike" of jaspilyte, but on re-examination very little more could be ascertained of its direction southwardly from the old mine. Yet I became more impressed with the probability of its resuming a direction about parallel with the direction of the mine at a short distance within the south wall, in the same manner as described of No. 2, last year.*

The Tower spur track cuts a light-green porodyte, 1450. This is mainly massive, except that it is basaltically close-jointed.

About five miles south-east from Tower, Mr. Hermann S. McMinn has conducted an exploration for Messrs. Andrews, Chapin & Co. This is on sec. 2, 61-15. Some samples of good magnetic ore, said to have been derived from this working, were shown at Tower, also some samples of the jaspilyte. Some of the jaspilyte is gray and white, with magnetite and pyrite (1451), interchangeable with jasper and hematite. Associated with the pyrite and magnetite is some graphite (1452). Much of it, so far as explored, is in the form of a breccia cemented by pyrite, now largely changed to limonite.

GLACIAL DIRECTIONS OBSERVED IN 1887. BY N. H. WINCHELL.

Bruce, Ontario, near the old Bruce mine, but east of it; on dioryte, at the lake level	S. 10° W. (Mag).
Bruce, Ontario, 50 feet above the lake, on quartz vein in dioryte	S. 10° W. (Mag).
Thessalon, left bank of the river, at the mouth, trap rock	S. 20° W. (Mag.)

[That form of cross-fracture glaciation that has been described on the Pipestone quartzyte in Minnesota is here seen frequently on the trap rock].

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*Fifteenth report, p. 235, fig. 4.

Thessalon, one mile S. E. from Little Rapids, on quartzyte	S. 20° W. (Mag).
Thessalon, crossing the last on the same surface	S. 30° W. (Mag).
Blind River, Ont., on quartzyte	S. 28° W. (Mag).
Cascade, five miles south of Negaunee, Mich., on conglomerate	S. 70° W. (Mag).
Lighthouse point, Marquette, Mich., greenstone	S. 25°-28° W. (Mag).
Bessemer, Mich., on Cupriferous conglomerate	N. & S. (Mag).
East end of Delta lake (west of Ogishke Muncie)	S. 14° W. (Mag).
Island in Pseudo-Messer lake (1433), green schist	S. 30° W. (Mag).

ROCK SAMPLES COLLECTED TO ILLUSTRATE THE REPORT OF N. H. WINCHELL, IN 1887.

Samples from the original Huronian.

1148. Red quartzyte from Port Finley, on the Canada side, north of St Joseph's island.

1149. Dioryte, Bruce; near the old Wellington mines.

1150. A fine diabase dike cutting 1149.

1151. From a great dike cutting 1149, running N. and S.

1152. Very fine grained, sometimes aphanitic and nearly black; near the mouth of the Thessalon river, west bank.

1153. Coarse-grained, speckled on the weathered surface; same place.

1154. Coarse-grained, speckled on the weathered surface; same place.

1155. Medium-grained and somewhat speckled with porphyritic feldspar, also with a reddish vein of granulyte; same place.

1156. Very fine grained, nearly black; east side, at the mouth of the Thessalon river.

1156A. Nodular, epidotic, veined condition of some of the rock at the mouth of the Thessalon, on the east side.

1157. Massive, dark gray, diabasic, resembling some seen in the railroad cut near Thompson, Minn.; from east side of the Thessalon.

1158. Epidotic trap rock, same place.

1159. Pitted and non-pitted and amygdaloidal rock, the amygdules being delessite; same place.

1160. The same rock, but having amygdules apparently of red felsyte; same place.

1161. Granulyte, or perhaps properly a protogine, same place.

1162. Gray quartzyte, about a mile northwest from Thessalon village.

1163. Felsitic quartzose gneiss, from a spur of 1162, embraced between two forks of a dike.

1164. From the main dike cutting 1162.

1165. From the smaller fork of the same dike.

1166. From greenish boulder-like masses included in 1162.

1167. Diabase unconformably overlying quartzyte, four and a half miles northwest from Thessalon.

1168. Coarse diabase, representative of the eruptive rock between Thessalon and Macbeth's bay.

1169. Pebbly quartzyte, 4½ miles N. W. from Thessalon.

1170. White, or slightly greenish-white, quartzyte, in the road two miles from the mouth of the Thessalon river, on the east side.

1171. Pinkish quartzyte, near Wm. Ensling's house, Thessalon valley, about two miles west of Little Rapids.

1172. Gray, fine-grained calcareous quartzyte, thin-bedded. Ansonia P. O. at "the dump."

1173. Sample of schistose slaty diabasic rock. Thessalon point, west side of the river. Logan's "green chlorite slate."

1174. Eruptive diabase, mouth of Blind river, west side.

1175. The same from the east side.

1176. Quartzyte, Blind river, east side.

1177. The same.

1178. Grayish red quartzyte, very fine-grained. Blind river, east side.

1179. So-called shaly portion of the gray quartzyte at the railroad cut. Blind river.

1180. Quartzyte, from the outer point west of the west arm. Blind river.

1181. Diabase dike, cutting No. 1180.

1182. Red felsyte, quartzose with fine, scattered grains; in patches in the diabase eruptive; somewhat affected locally by contact with the basic eruptive. R. R. cut on the east side of the Missasaugui.

1183. Light-greenish quartzyte, a phase of the quartzyte at the R. R. cut on the east side of the Missasaugui.

1184. A condition of the quartzyte at the same place in association with the diabase, the quartz losing some of its distinctness.

1185. The same, more dark.

1186. The same with an orthoclastic tendency.

1187. The same converted to red fibro-basaltified felsyte.

1188. The basic eruptive with red orthoclase crystals disseminated, same place.

1189. Same as the last, but finer-grained, same place.

1190. Dioryte, west side of the Misssasaugui, at the mouth.

1191. Fine-grained gray, flinty-quartzyte, showing an abrupt contact on 1190.

1192. Shows one of the greenish-weathering, more slaty parts of this quartzyte from the opposite side of the river.

1193. One mile west of "the dump," orthoclastic granulyte.

1194. Fine, gray, bedded "slate," broken and again cemented by many veins of quartz; sec. 8 Le Froy; hardly slaty, rust-coated.

1194A. Small bits from 1194, showing black metallic oxide, and some amethystine quartz.

1195. Red felsyte; ridge near Otter Tail P. O.

1196. Gray quartzyte, approximating the last in its felsitic aspect.

1197. Same as the last, but varies to a reddish quartzyte.

1198. Same as 1196, but varies to a gray quartzyte.

1199. From a hill in line of strike from 1195, being a portion of the same ridge toward the N. W.; a brownish, red-weathering felsitic rock, with a confused structure as if originally a conglomerate, containing much free quartz, and finely, but sparsely porphyritic with red feldspar.

1200. Gabbro, from near Otter Tail P. O.

1201. "Lithographic stone"; bottom land of Thessalon on Mr. Day's "limits," about a mile below Otter Tail lake.

1202. The same, showing free quartz in rounded grains.

1203. Gabbro, or dioryte, similar to 1200, about N. E. ¼ of sec. 23, Plummer.

1204. Red felsyte; one mile south of Murray's corners, SE. corner of sec 2, Plummer.

1205. The same, subcrystalline.

1206. Fine-grained, argillitic slate, 12 rods S.W. from 1205, forming conspicuous ridges that strike N. W.

1207. Crystalline condition of 1205, a little further N. W. from 1205, but in the same ridge as 1205; reddish seynite.

1208. Non-weathered portion of the same rock as 1207; a gray syenite, or quartz dioryte.

1209. Grayish-green "slate conglomerate," containing granite pebbles. Murray's hill, at Murray's corners.

1210. Dike-rock cutting 1209, at Murray's hill.

1211. Reddish felsitic quartzyte, one-half mile south of Murray's corners, on Hugh Matheson's land.

1212. At 1¼ miles S. W. from Otter Tail P. O., slate conglomerate similar to that at Murray's hill.

1213. Quartzyte interbedded in these slates; like 1211.

1214. Pebble from this slate.

1215. From "the dump," Ansonia P. O. the rock adjoining 1172, on the lower side, a rough, reddish felsyte.

Samples from the Marquette Region.

1216. Micaceous hematite, Cascade, five miles south of Negaunee.

1217. Hematite, showing the bedded structure, some of the layers being pebbles of quartz, Cascade.

1218. Quartz-conglomerate grit, unconformable above the ore beds at Cascade, upper portion.

1219. The coarser, lower portion of the above conglomerate, within three feet of the contact plane.

1220. "Chalcedonic silica" from Palmer (Cascade).

1221. Sample of the unconformable quartzyte-conglomerate near the contact with the ore-formation two and a half miles west of Ishpeming, at the old Saginaw mine.

1222. Same at 20 rods north, rising 20 feet higher.

1223. Granular quartzyte, one mile west of Ishpeming.

1224. Slaty rock, interbedded, but overlying the last; slight exposure in the road.

1225. Two and a half miles N. W. from Ishpeming; a pebbly greenstone, also porphyritic, with some bits of broken schist.

1226. Sample of the main ridge, from which the last was obtained, at the southeastern side of Deer lake.

1227. Sample of the country schists, nearly adjacent to the ridge (1226) on the south side.

1228. Purplish to reddish, fine-grained quartzyte, at the railroad cut a little further west.

1229. Massive, basaltic greenstone; same railroad cut.

1230 Basaltic, conglomeritic greenstone; same place.

1231. Chemical limestone, from the serpentinous rocks at the Ropes gold mine, five miles N. W. from Ishpeming.

1232. Talc, associated intimately with 1231.

1233. The rock of the country at the Ropes gold mine, apparently the same as 1225, 1229 and 1230.

1233A. Sample of the quartz vein, Ropes mine.

1234. Fine-grained reddish quartzyte; east side of the river below Dear lake.

1235. Green "soapstone," with martite; Cleveland mine.

1236. Light, sericitic soapstone; Cleveland mine.

1237. Martite, in green "soapstone;" Cleveland mine.

1238. Magnetic quartz schist, passing to iron ore; Michigamme mine.

1239. Dioryte, from a knob near and north from the Michigamme mine.

1240. The so-called granite from the range next north of Michigamme, three feet from the contact.

1241. Contact between the quartzyte and granite, the former taking a gneissic structure.

1242. Quartzyte.

1243. Between the conglomerate and this quartzyte this rusty-green, micaceo-pyroxenic material is found, about three inches thick.

1244. From a dike 14 inches wide, cutting the granite; fine-grained, altered.

1245. South from the granite range on isolated crags of gray, fine, siliceous schist, and on the upturned edges are weathered out the forms of small, garnet-like crystals.

1246. Samples of this same gray schist, or quartzyte, with the sedimentary structure evident.

1247A. Coarse, fragmental, tough.

1247B. Hematite, interbanded with impure, reddish, chalcedonic silica.

1247C. Jasper rock, banded and clouded.

These three change by innumerable gradations from one to the other. From the Swan mine, near Negaunee.

1248 Greenish quartzyte or graywacke; near the railroad cut, north side of the Buffalo property, east of Negaunee.

1249. Black slate, graduating downward into

1250. A contorted, greenish slate which lies, possibly unconformably, on the slickensided upper surface of 1248.

1251. From an old, much changed dike, north side of the Buffalo property.

1252. Iron-bearing condition of 1249, from the north side of the railroad, north of the Buffalo mine.

1253 Gray quartzyte, that cuts off the ore in the Iron Cliffs mine, near Negaunee.

1254. Nearly white, granular quartzyte, north side of Teal lake.

1255. Changed dike, cutting 1254, crossed by bands of color, due to different degrees of infiltration of iron-stain.

Samples from the Gogebic Iron Range.

1256. Alternating forms of the country rock, at the Colby mine, near Bessemer, Michigan.

1257. South wall, Colby mine.

1258. Siliceous slate; spur track from the Colby to the Valley mine.

1259. Sample of ore from the stock pile, Valley mine.

1260. Hornblende granite, south from the Aurora mine.

1261. Gray quartzyte, overlain by granite, south of the Aurora mine.

1262. Quartzyte slate, overlain by granite, south from the Aurora mine.

1263. Black slate, from a deep well drilled a short distance east of the Iron King mine.

Samples from Minnesota.

1264. Gabbro, on the Rove lake road, near the south foot of Pine mountain.

1265. Red rock, Brulé mountains, north from Pine mountain.

1266. From a boulder, N. E. ¼ of sec. 19, 64–1E.

1267. Amygdaloidal porphyry, from boulders, south from the North Brulé. [This sample seems to have been lost].

1268. Shows contact between rock 1266 and the red rock.

1269. Gabbro-like rock, north side of sec. 19, 64–1E.

1270. Gneiss, on the trail to Northern Light lake, a short distance north of North lake.

1271. Oolitic bloodstone, from a boulder near North lake.

1272. Hardened Animike, at the rapids going out from North lake.

1273. Dense trap, just west of the rapids last mentioned.

1274. Syenite, a short distance further west, north shore.

1275. Trap (gabbro), at a mile west of the entrance of the river to Gunflint lake, north shore.

1276. Modified "gunflint" beds of the Animike, north shore of Gunflint lake.

1277. Flint from the Animike, north shore of Gunflint lake.

1278. Kewatin schist, mouth of the creek, east end of the long bay, north side of Gunflint lake.

1279. Porphyritic rock, associated with No. 1278.

1280. Probably an old eruptive, belonging to the Kewatin, north shore of Gunflint lake.

1281. Changed graywacke, Kewatin; north shore of lake.

1282. Gray gneissoid rock, slightly porphyritic, north side flint lake.

1283. Porphyrel; bluff, north shore of Gunflint lake.

1284. Argillitic slate, interbedded with 1283.

1285. Argillyte, bedded in the rocks 1281 and 1282.

1286. Some of the changed graywacke, same rock as 1283.

1287. The gray rock on which the gabbro lies; at the iron location, Iron lake.

1288. Magnetited gabbro, Iron lake, from points west of hew location.

1289. Drift boulder of the gray rock near the bottom of mike. To find the cause of the rusty coating. Iron lake.

1290. A drift piece from the same place, shows a possibl from magnetite to limonite.

1291. Sample of the Iron lake ore.

1292. Sample of the same showing olivine?

1293. From a boulder. Iron lake, showing micaceous co itic gneiss.

1294. Limonitic pebbly conglomerate, and breccia, on a north from Gunflint lake, on the town line (if extended) be 65-1 and 65-2 W.

1295. Jaspery and flinty portions of the last.

1296. Kewatin sericitic schist, same traverse.

1297. Sericitic porphyry, same traverse.

1298. Soft sericitic schist, same traverse.

1299. Micaceous rock, interbedded with the Kewatin schi traverse.

1300 Represents the hornblendic part of the black, best.

1301. Syenite gneiss, same traverse.

1302. Gneiss, or granite, end of the same traverse.

1303. Trap rock from a dike in this gneiss.

1304. Shows a blending of the characters of the mica sc those of the porphyry.

1305, 1306, 1307. Three different stages in the change black fine-grained rock to the rusty film characteristic of so Animike.

1308. Iron ore, near the east end of Gunflint lake, north

1309. A condition of "muscovado," at the same place, n tact with the gabbro.

1310. Brecciated and angular fragments of flint and other dark rocks, north shore of Gunflint lake.*

1311. Is another stage of this rusting rock; effervesces.

1312. A condition of the trap, at the narrows, black and close-jointed.

1313. Muscovado-like rock, west of the narrows.

1314. Porphyritic gabbro, or trap, Animike bay.

1315. Jasper-flint-quartz-magnetite schist; shore south of Black Fly bay.

1316. Gneiss; north side of Black Fly bay.

1317. Enclosed hornblendic rock in 1316.

1318. Darker portion of the gneiss, at the first falls north of the narrows going out from Gunflint lake. (This sample was lost.)

1319. Fine siliceous "muscovado," north side of the point that lies north of the Animike bay.

1320. Siliceous "streamed" gray rock, a condition of 1319.

1321. Magnetite, associated with 1320.

1322. Granular quartzyte, gray, in fallen masses, north side of the same point.

1323. Gabbro, at the top of the hill north of Animike bay.

1324. Black slate, from near contact with the gabbro.

1325. Ore with chert, &c. N. W. cor. of sec. 23, 65-4.

1326. Ore without chert, same place.

1327. Underlying gray sandrock or quartzyte.

1328. Gneiss, from the shaft, N. W. cor. sec 23, 65-4.

1329. From a dike, N. side of sec. 22, 65-4.

1330. Greenstone, near the quarter post between secs. 20 and 21, 65-4.

1331. Schisted conditions of this rock.

1332. Top of the slope, same rock as 1330.

1333. Similar greenstone, in a ridge about 30 rods south of the last.

1334. Most southerly exposed part of the same greenstone.

1335. Rock of the hill north of Chub lake, a rather indefinite greenish rock.

1336 Iron ore from the excavation near Chub lake.

1337. Pieces from greenstone and gneiss pebbles, below the ore. Chub lake.

1338. Gray quartzyte, associated with this ore.

1339. Hornblendic portions of the strata associated with the ore at Chub lake.

1340. Purplish-gray, vitreous quartzyte, ⅛ mile west of the ore pit. Chub lake.

1341. Porphyritic gabbro near the top of the Pewabic quartzyte. Chub lake; interbedded in the quartzyte.

1342. Reddish gneiss, but a short distance north of Flying Cloud lake.

1343. Pewabic quartzyte, sec. 25, 65-5.

1344. Gabbro interbedded in the Pewabic quartzyte; sec. 25, 65-5.

1345. Same indefinite greenstone as 1335; from the hill south of Bingoshick lake.

1346. Greenstone, at the south shore of Bingoshick lake.

1347. Muscovado, from the shore of Muscovado lake, sec. 36, 65-5.

1348. Labradorite rock from the north part of sec. 11, 64-5, south side of Bashitanekueb lake.

1349. Talcose slate, a schistose greenstone, from a fragment seen on the portage from Kakego lake to Clothespin lake.

1350. From the north side of the point, sec. 32, 65-5, Gabemichigama lake, showing apparently a finely fragmental condition of the rock that lies below the gabbro.

1351. S. W. ¼ sec. 29, 65-5; fragmental, sedimentary tilted Animike.

1352. Same as 1351, but coarser.

1353. Same as the last, but still coarser, a gray grit.

1354. Samples of Animike, obtained a little south of the centre of sec. 29, 65-5.

1355. Animike, from N. E. ¼ sec. 31, 65-5, shore of Gabemichigama lake, bedded with rock like 1354.

1356. At about the center of N. E. ¼ sec. 31, 65-5, Ogishke conglomerate.

1357. Fine-grained beds, siliceous, granular, a little N. E. from the last.

1358. Gray feldspathic rock, south shore of Gabemichigama lake, where the Ninth correction line intersects the shore.

1359. Biotitic gneiss, from the same place as the last.

1360. A little further west, gabbro.

1361. About on the town line between 64-5 and 64-6 W., secs. 6 and 1, basaltic greenstone dike.

1362. Pewabic quartzyte, magnetited, hornblendic, etc., from the iron cliff on the south side of Gabemichigama lake.

1363. From near the bottom of the same cliff.

1364. Also from near the bottom, freshly exposed by a landslide.

1365. A little northeast from the "narrows" of Gabemichigama lake; heavy, banded, olivine-bearing quartzyte.

1366. Gabbro, fine-grained, just at the entrance to the narrows, interbedded with Animike.

1367. Various samples obtained in the ascent of the hill from the shore of Gabemichigama lake, situated at the west side of the lake, intended to show the features that might be considered of sedimentary origin.

1368. Various samples from the same, which seem to be of true doleryte, from near the summit of the same hill.

1369. So-called marble, N. E. end of Ogishke Muncie lake, sec. 24, 65-6.

1370. Argillitic slate, lying next west, along the lake.

1371. Sample of the "marble," from the hill, further east, involved with the greenstone conglomerate.

1372. Samples of the greenstone conglomerate, with traces of sedimentary structures, and fragments of other strata involved, sec. 24, 65-6, shore of Ogishke Muncie lake.

1373. Small contorted masses of cherty argillyte embraced in the same conglomerate.

1374. Rounded, concretionary, or pebble-like, small masses, resembling, or suggesting shells, seen on a weathered surface of the same conglomerate.

1375. In sec. 13, adjacent to the above, in the narrow place between Ogishke Muncie lake and the lake south of Townline lake. Schistosely disintegrating, light green and siliceous condition of the same conglomerate.

1376. Greenish argillyte, from this conglomerate.

1377. Piece of a pebble from the conglomeritic part.

1378. Rusty carbonate, appears in patches in this rock.

1379. Gritty greenstone, south end of the east bag of Saddle Bags lake, on the town line between 65-5 and 6.

1380. The same from the east side of the east bag of Saddle Bags lake.

1381. Greenstone from the west side of Frog Rock lake.

1382. The same from near the center of sec. 19, 65-5, south of Frog Rock lake.

1383. Greenstone rock from the center of the same section.

1384. Associated with the last, interbanded with it, and finer-grained.

1385. Argillyte showing fine ripple-marks, west end of Ogishke Muncie lake.

1386. Rock from the summit of the East Twin mountain, a coarse greenstone.

1387. Finer greenstone, from the north slope of the same hill.

1388. Coarser greenstone again, nearer the base of the main hill, apparently eruptive rock.

1389. Both coarser and finer, at the bottom of the same hill.

1390. Greenstone from the subordinate, more northerly hill-range.

1391. Flinty quartzyte, incipiently porphyritic; from the same subordinate ridges.

1392. Imperfectly porphyritic quartzyte, or cherty-quartzyte, and black chert, same hill range.

1393. Further north; rock representing several small hills or hill-ranges; a gritty greenstone, a modified sedimentary.

1394. Chalcedonic silica, and samples closely related, all inclosed in and banded together in 1393. Same hills.

1395. Conglomeritic "greenstone," showing some sedimentary structure of itself, a widely disseminated rock, same hills.

1396. Hardened and basaltic graywacke, from the hill directly east of Alpha lake.

1397. Dike (?) cutting the same, near the lake shore.

1398. Porphyry (or porphyrel), S. W. corner of sec. 29, 65–6.

1399. Weathered surfaces of the same.

1400. The same porphyrel, from the south side of the lake, in close proximity to the great dike of Kekekebic lake.

1401. The dike which crosses Kekekebic lake. This forms two islands in the lake.

1402. The rock on west of the dike in the southerly of these islands; fine, red-weathering gneiss. The sample is gray.

1403. A little further west, the same gneiss, somewhat approaching the porphyry 1400.

1404. Hardened graywacke-like greenstone, from a ridge near the center of sec. 31, 65–6.

1405. Quartzose rock with a finely porphyritic tendency. From the point N. W. ¼, S. W. ¼ sec. 31, 65–6, on the south shore of lake Kekekebic.

1406. Greenish-schist conglomerate, same place as 1405.

1407. Porphyry, south shore of lake Kekekebic, at the narrows.

1408. Porphyry, from the island west of Stacy island.

1409. Chloritic schist, from the litte island just west of the narrows, near the north shore.

1410 From the top of the same island; the same rock.

1411. From the middle of the south cliff, same island; more siliceous, and showing sedimentary banding.

1412. The same, near the water, having boulders of rock like itself.

1413. The same, with hard lenticular sheets.

1414. Near the south side of sec. 35, 65–7; different forms of porphyry in a low bluff at the shore.

1415. The same place; the greenish rock underlying 1414.

1416. Reddish porphyritic gneiss, showing the intergrading of the gneissic, the porphyritic and the conglomeritic characters of this rock.

1417. The same rock; Shingwak island (north of Animike I.) in Kekekebic lake.

1418 From the same island; the red crystals being in bands that alternate with others of a greenish biotitic rock.

1419. From a very small island directly south of Shingwak island; a fine-grained greenish graywacke.

1420. West end of Animike island.

1421. S W. end of lake Kekekebic; sec 4, 64–7. Somewhat micaceous (biotitic) conglomeritic.

1422. From a small island south of the point, west part of sec. 3, 64-7; a greenish rock, with sparsely disseminated red crystals.

1423. Green schistose conglomerate; at the head of the bay on the town line, west end of Kekekebic lake.

1424 Pebble like forms in 1423.

1425. From a dike, north shore of the same bay.

1426. S. E. ¼ of sec 34, 64–7, near the head of the broad shallow bay. the greenish, graywacke beds seem to show a tendency toward the characters of the porphyry.

1427. Found on the portage from Spoon lake northward. A fragment showing the "red rock" in veins cutting the biotitic gneiss.

1428. The rock forming the point in Knife lake N. E. cor. sec. 28, 65-7, a dark siliceous slate.

1429. At the summit of the divide, on the first portage from Knife to Pseudo-Messer lake, siliceous slate.

1430. Gabbro, a little below the summit and on the north slope, same portage.

1431. At the portage-landing, south side of Pseudo-Messer lake. Argillitic slate.

1432. From the point north from the portage-landing, on the east side, in Pseudo-Messer lake. Reddish-weathering, pyritiferous gritty felsyte, firm and sharp in fracture.

1433. Directly across the Pseudo-Messer lake, from the portage-landing, soft schistose greenstone, with "chalcedonic silica" and jaspilyte.

1434. Chalcedonic silica, so-called, embraced in lumps in 1433.

1435. Hematitic jaspilyte, embraced in the same.

1436. Micaceo-syenitic gneiss; sec. 10, 64–10, Bassi-menan (or Basswood) lake.

1437. Mica schist, from S. W. ¼, sec. 5, 64–10, long peninsula in Bassi-menan lake.

1438. Changed graywacke, from the S. E. end of the portage, S. E. ¼. sec. 6, 64–10.

1439. Bluff on the right bank, just below the Pipestone rapids, greenstone.

1440. Fine mica schist, same bluff.

1441. Light-colored, reddish, chloritic granite. Cuts 1439 and 1440.

1442. Just above the rapids, right bank, from large pieces apparently derived from the bluff, the rock *in situ* being hid.

1443. Shining sericitic schist, from the portage from Newton lake to Fall lake.

1444. Greenstone that replaces abruptly the jaspilyte, at the head of the portage from Fall lake to Garden lake.

1445. Quartzyte, at the place known as Silver city, at the rapids between Garden and White Iron lakes.

1446. Eleven samples showing the variations in this rock, and the associations of the ore.

1447. N. E. ¼, S. E. ¼ sec. 28, 63–12 on the north shore, not far east of Silver city. A firm dark rock, in some places schistose by decay.

1448. Greenstone, N. W. ¼ sec. 4, 62–14. Recent drilling for iron has been done here.

1449. White schist, (talc?) from the Stone mine, Tower.

1450. Light-colored, green siliceous rock, mainly massive; cut by the Tower spur track from the mines.

1451. A form of the jaspilyte that is gray and white, with pyrite and magnetite, sec. 2, 61–15, interchangeable with jasper and hematite.

1452. Graphite, associated with the same.

1453. Asbestine ore, Black River Falls, Wis., associated with the magnetic ore of the York opening.

1454. Asbestine with a fold in the fiber, Black River Falls, Wis., at the York opening.

1455. Granite, near the furnace of the York Iron company, Black River Falls.

1456. Gray jaspilyte, a form from Black River Falls, Wis., just southwest from "Mound No. 1," near the river, and nearest the granite. The bedding is about vertical but curiously twisted and curled, strike nearly east and west. This is the most southerly point at which (here) the magnetic quartz-schist can be seen.

[*Note.*—The "soap rock" here is the sericitic schist, and is apparently a rock with a sedimentary comformability with the magnetic schist. The magnetic schist varies to a hematitic schist. It is magnetic at the York opening, and hematitic at the Dubuque. The latter underlies the former, and they both seem to run below the granite in the river adjacent at an angle which is generally 15°, but at the York opening, near the river, is no more than 2°. A dike of rotted greenstone runs about E. and W. across the mound. It is seen at the opening near the river, at the west end, and again at the opening further east, in a similar ore, cutting diagonally across the sedimentary structure.

The sedimentary bedding in all the "ridges" containing iron ore in the vicinity of Black River Falls, has a dip toward the south, i. e. toward the granite and not toward the north away from the granite. The latter was reported by the Wisconsin geologists.]

The following is a list of the specimens taken and described by Mr. Stacy to illustrate his excursions on the north shore of Gunflint lake. The order in which they are numbered is that in which they were discovered in the excursion from the lake shore, northward.

EXCURSION I.

1457. Outcrop at water's edge—fine-grained light-gray slate—strike E. 18° N. (This is the true meridian.)

1458. 30 feet north of shore—coarse-grained oolitic slate, resembling siliceous graywacke.

1459. 40 feet north of shore—dark oolitic slate—strike E. 12° N.

1460. 400 feet north of shore—dark siliceous slate—strike E. 12° N. —occurs in bluff 60 feet high and 80 feet broad at summit.

1461. 600 feet north of shore—gray compact granular schist, somewhat massive and finely oolitic—occurs interbedded with same slate as 1460.

1462. 1200 feet north of shore—in bluff 100 feet high, black fi grained slate.

1463. Same location—same slate more siliceous and oolitic w specimen of trap in contact.

1464. Same location—similar to 1461, but coarser, pebbly, a phyrel with graywacke-like base: two samples.

1465. Same location—trap-like schist, greenish-gray, somew sericitic—occurs irregularly interbedded with 1462-3, and often pearing to intersect more as a dike.

1466. Same location—a form of 1465 more distinctly laminated schistose resembling sericitic schist, a weathered condition of 146

1467. Same location—a dark, tough, trap-like rock occurring dikes with 1462-3, and resembling a fine-grained gabbro.

1468. Same location—same as last, finer-grained, more weathe the weathered surface exhibited.

1469. 1600 feet north of shore—gray, compact, flinty argillac rock, schistose but unlaminated.

1470. Same location—micaceous porphyrel interbedded with 14 two specimens.

1471. 1800 feet north of shore—dark-gray hydro-mica schist, s ilar to lustrous graywacke, like 1470 but not porphyritic—occurs terbedded with chert and slate, resembling 1462 and 1469.

1472. 2700 feet north of shore—black siliceous slate—occurs successive bluffs interbedded with a more massive slate.

1473. A porphyrel which occurs with the slate.

1474. Same location—massive, lustrous, siliceous slate in th laminæ interbedded with 1472—abounds in many bluffs for a qua of a mile northward.

1475-6-7-8. 3500 to 4000 feet north of shore—different condition apparently the same rock in varying stages of decomposition: 1 being trap-like, compact and dark; and 1475 being light greenish gr thinly laminated, and apparently a hydro-mica schist.

The last specimens occur in an immense bluff of from 150 to feet elevation and are irregularly interbedded with the dark sl 1472-4, and much contorted in places. The bluff at the highest p of elevation is capped with gabbro. A swamp lies immediately a of the bluff at a descent of nearly 200 feet

EXCURSION II.

Specimen 1479. 50 feet from shore—sericitic micaceous porphy

1480. Same location—cherty schist.

1481. Same location—slate—strike varies from E. 12° N. to E. 18° N.—Note: 1479–80–1 occur interbedded for 500 feet northward.

1482–3. 550 feet north of shore—micaceous sericitic schist—occurs with 1481 and extends northward 400 feet, graduating into 1484, &c.

1484–5–6–7. 800 to 2000 feet north of shore—chloritic, micaceous and hornblendic schists, varying from massive to schistose according to weathering, and occurring in numerous ridges and knolls.

1488. Same location—flint-like and massive—occurs in ridge in swamp.

1489. 2500 to 3000 feet north of shore—lustrous, dark gray, micaceous and sericitic schist—occurs interbedded with slate and chert.

1490. Same location—hornblendic, trap-like micaceous schist, pebbly and granular—interbedded in slate and chert.

1491. 3500 to 5000 feet north of shore—syenitic porphyrel, appears to contain hornblende and feldspar crystals in a sericitic base—[This is the beginning of the black belt formation].

1492. Same location—same as 1491, but more sericitic and schistose.

1493. Same location—hornblendic and feldspar schist.

1494. Same more micaceous.

1495. Black lustrous mica and hornblende, fine-grained schist like that found a mile east—[This is the black belt sought].

1496. Same as 1495—showing contact with the syenitic porphyrel.

1497. Hornblendic, sericitic schist.

1398. Hornblendic gneiss, containing large black crystals.

1499. Gneiss.

1500. Syenite—mile and a quarter, or about, from lake.

Specimens 1491–1499 are of one formation and lie in successive terraces and ridges for over a quarter of a mile until 1500 is reached.

REPORT OF A. WINCHELL.

PORT OF A GEOLOGICAL SURVEY IN MINNESOTA DURING THE SEASON OF 1887.

MBRACING COMPARATIVE OBSERVATIONS IN SOME OTHER REGIONS.

BY ALEXANDER WINCHELL.

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§ 1.—PRELIMINARIES.

.—*The Regions covered by the observations of* 1887. The first part of season was devoted to comparative observations in the region of typical Huronian formations north of lake Huron; to a review of tions of the Marquette iron-bearing region, a brief visit to the ;ebic range, and a study of the geology of the Penokee Gap. These lies upon territory already worked up, to a considerable extent, by erican and Canadian geologists, seemed indispensable to a proper relation of the rocks of northeastern Minnesota with the facts ex- ng in other parts of the continent, and the interpretations which been placed upon them by preceding investigators.

Vith this preparation, work was resumed in northeastern Minne- ι, and, before the end of the season, was carried to the extreme it of the state. In reaching the meridian at which the operations last season were interrupted by the advent of inclement weather, nbraced the opportunity to supplement and complete observations some portions of the territory covered by my report of 1886—es- ially in Burntside, Basswood and Sucker lakes. Parts of Garden were also subsequently reviewed. The territory new to my own lies extends from Range 7 west to Range 5 east, and from Town 64 th to Town 67 north, and beyond, into Canadian territory; or from western extremity of Knife lake to Grand Portage on the east, and northern shores of Saganaga lake, on the north. The actual ob- ations extended into eighteen different townships. The following the lakes whose shores were geologically investigated:—Burntside, wood. Sucker and Garden, supplementarily; Pseudomesser, Knife, rtrack. Oak, Saganaga, Red-Rock, West Seagull, Seagull, Granite, , Gunflint, Loon, Iron, North, South, Rose or Mud, Rove, Moun- , Moose, North Fowl, South Fowl, Frog-Rock, Townline, Ogishke-muncie, Crab, and Epsilon lakes. The vicinity of the streams connecting these lakes was also studied. Of these, the Boundary river, flowing west, and Pigeon river, flowing east, are the most important.

2.—*Conditions of the exploration.* The mode of travel, as last season, has been by birch bark canoes, over the numerous lakes and navigable streams, and intervening portages. To accomplish the geological work of the season, ninety-six portages had to be made, aggregating thirty-eight miles. When the time and labor necessitated by the portages are considered, with the time and labor occupied in affairs about camp and in protection against bad weather, together also, with the time required for paddling several hundred miles, it becomes apparent that the net time and strength left for actual scientific work are comparatively meagre. When it is further considered that the actual work has to be carried on, many times, under most difficult circumstances—over mountain precipices, in deep, slippery gorges, along high and almost inaccessible cliffs, under the intense heat of a summer sun, or the chilling effects of a drizzling rain, with the haste sometimes necessitated by an impending storm or an approaching sunset, and all in the midst of an incessant and bloody conflict with the northern hordes of merciless insects, it must become apparent that geological fieldwork in a region like this is difficult and fatiguing—far from the summer pastime which is sometimes pictured. But though such statements seem required for a just appreciation of the labors of the geologist, it must be understood that his work is prosecuted with a cheerfulness and zeal inspired by a love of nature, even under her rudest aspects, and a thirst for knowledge which knows no discouragement in the pursuit of its gratification. Of peculiar interest has been the work in northeastern Minnesota, since, in addition to being a field little known, it promised to supply the facts which would point to a final solution of long pending geological problems.

3.—*Physical aspects of the region.* No conspicuous features of mountain relief traverse the country, though a low, interrupted swell, called the Giant's range, trends east and west through the sixty-fifth tier of townships, becoming most conspicuous in range 4 west, and continuing eastward into Canada; and another series of still higher reliefs, stretching through the south part of tier 65, and westward into the north part of tier 64, is known as the Mesabi range. This is not the Mesabi range of the vicinity of Tower.*

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*On these ranges, see N. H. Winchell, Thirteenth Ann. Rep., 1884, pp. 20-21.

The Giant's range is formed by an uplift of syenite, which in breadth stretches northward to the north part of Saganaga lake and southward to near Gunflint lake, and, with a southwestward continuation, which will be considered in due connection. The east-west ranges which culminate in the so-called Mesabi range are formed of gabbro, resting chiefly on cliffs of Animike slate, and their geology will also be considered in the proper connection. The gabbro-crowned hills occur in the eastern portion of the district examined, and impart to it an exceedingly rugged character. The ranges present, generally, an abrupt descent along the northern aspect and a gentle descent toward the south. The northern slope consists mostly of a vertical precipice of rudely columnar gabbro at the summit, with a vertical wall of slate beneath, and a long talus of fragments sloping to the water level. The gabbro precipice is sometimes fifty to one hundred feet high. This measures the thickness of the gabbro covering the country. The slate cliff has generally an equal thickness; and the vertical hight of the talus is even greater. Between the east-west ranges the little lakes are lodged which supply the chief means of communication across the country. A sparse growth of jack pines once covered these gabbro ranges, but at present they are almost completely denuded. A little soil is accumulated along the southward slopes of the ranges and the northern lake borders; but, as a general statement, the surface is rugged and uncultivable. The regions of syenitic outcrop are even more rocky and sterile than the gabbro district. It is impossible to conceive a country of more desolate aspect than that along the rapid Boundary river between Granite and Gunflint lakes. The entire region bordering Seagull, West Seagull and Saganaga lakes is, with the exception of occasional small tracts, a continuous, undulating floor of shattered syenite. The region of Knife lake, with its long arms, lies north and west of the syenite of the Giant's range; but the schists weather in beetling cliffs and rugged contours, affording but contracted space for forest growths, and supporting little soil adapted to cultivation. Still further west, the physical features become more subdued, especially in the parts underlaid by schists; but the granite borders of Basswood lake, like the northern border of Burntside, still further west, present a forbidding aspect to the agri culturist; while along the Boundary river, northwest of Basswood lake, the granite region presents its characteristic barrenness fully developed.

4.—*Aspects of the vegetation.* The region between Fall lake and Grand Portage, and north of Grand Marais, is a literal wilderness without inhabitant, without mails, without roads, and with only an occasional party of Indians or explorers, following the ancient and overgrown trails of two centuries ago. Fires have denuded the region of its primitive forest; but the older burnings are becoming overgrown chiefly by dense thickets of the trembling aspen (*Populus tremuloides*), and in places, by the white paper birch (*Betula papyracea*). with occasional cherries (*Prunus pennsylvanica*). Remnants of the original forest consist of white, Norway and Jack pines, balsams, spruces and cedars, with intermixtures of white birch, aspen and balsam poplar (*Populus balsamifera*). In very limited areas, the white and Norway pines have attained noble dimensions—especially along the Pigeon river. On the portage between Rose and Rove lakes, I measured a white pine three feet in diameter. Other large examples of white and Norway pines were scattered about. In the more strictly granitic regions,the Jack pine (*Pinus banksiana*) slender and mast-like, forty to sixty feet high, is, or has been, almost the exclusive occupant, maintaining its hold in situations where neither soil nor moisture would seen accessible. In some districts, especially the syenitic regions along the Giant's range, where fires have swept over the surface, the skelton forms of the slender Jack pines still stand like huge bristles along the crests and slopes of the rugged ridges.

In the soil-covered tracts. an undergrowth of striped maple (*Acer spicatum*) frequently exists, which thrives with amazing luxuriance, while in the openings, and over many burned areas, the red raspberry flourishes and fruits in great productiveness, regardless of the stony nature of the soil; and the welcome, unpretentious blueberry holds possession of granitic and schistic knobs, even when deserted by all other forms of woody vegetation. The raspberries, during August and September, supply an abundant and very welcome article of food. The former are found at the same time, especially during September, in all stages of development, from the green fruit, just out of flower, to the ripe fruit on the same stem. This ever-bearing variety would seem to be worthy the attention of horticulturists.

The blueberry (*Vaccinium canadense*) flourishes with luxuriance in inverse ratio to the amount of soil. On the most rocky hills it fruits in such abundance as to impart a blue aspect to a distant slope. At Blueberry rapids, in the Giant's range, I cut one stem with four elongated clusters of large berries, and in one cluster were seventy-two berries. On a granite hill near the Pigeon river, I observed a distinct form of blueberry growing side by side with the ordinary form. Its hight was only about two inches, and very uniform, but it bore abundant large pear-shaped berries, somewhat less sweet and meaty than those of the ordinary form. If this is the dwarf blueberry (*Vaccinium pennsylvanicum*), the shape of the fruit ought to be mentioned as a characteristic feature. I never saw it in any other situation.

Most of the low grounds are occupied by the common alder (*Alnus viridis*), and this hardy shrub frequently overhangs the borders of the lakes and streams. But a more frequent fringe of the waters is formed by a luxuriant growth of the fragrant-leaved bayberry (apparently *Myrica gale*), which weaves a barrier almost impassable. With the alders, but more generally grouped by themselves, are species of willow not exceeding the alders in hight. Four species of cherries have been noticed, of which the wild red cherry (*Prunus pensylvanica*)—a sort of choke cherry, is most generally distributed. The racemed black cherry (*P. virginiana*) having also a choking quality, and apparently the well known red choke cherry, is found frequently on rocky taluses; and the fine large-fruited, black dwarf cherry (*P. pumila*) is occasionally met along the borders of lakes, keeping company with *Myrica* and *Azalea*. The sweet black cherry (*P. serotina*) is occasionally seen. The fire-red fruit of the mountain ash (*Pyrus arbutifolia*) frequently gleams through the prevailing green and brown of the lakeside foliage; and in the far east and along the Pigeon river, the high cranberry (*Viburnum opulus*) in its fruiting season is similarly conspicuous.

Among the low herbs, the dwarf, scarlet fruited cornel (*Cornus canadensis*) is generally abundant, growing both in dry and moist situations. With this, but rather preferring the low grounds, is the purple fruited orchid (probably *Platanthera obtusata*). A species of blue-flowering aster is very wide-spread, often covering the ground, and the bristly sarsaparilla (*Aralia hispida*) is quite frequently encountered. Sedges and grasses hold uplands sparsely, but appropriate somewhat exclusively the situations deficient in drainage; while rushes—especially *Juncus balticus*, flags (*Typha latifolia* and *Acorus calamus*), and wild rice (*Zizania aquatica*) encroach widely on the areas covered by standing water.

Many small tracts of deep and productive soil intervene between almost universal rocky, or thinly covered, exposures. At the south end of the portage from South Fowl lake, I measured, at the end of August, a Balm of Gilead shoot of the season's growth, forty-nine inches in length. A similar shoot north of Gunflint lake, measured six feet and three inches. The white pines already mentioned supply similar indications. A large tract of pasture land and arable soil lies o Pigeon river, in township 64, ranges 4 and 5 east; but the g part of this falls within the Indian Reservation.

5 —*Quadrupeds and other vertebrates.* Among the quadrupe the region, the common northern hare (*Lepus americanus*) is o the most abundant; and, to the skilled methods of trapping kno the Indian, yields a considerable supply of savory food, whil white winter pelage is esteemed as material for handsome robes. porcupine (*Erethizon dorsatus*) is not unfrequently met, and also a coveted article of food. The black bear (*Ursus american* an inhabitant of the region, and is sought, at the suitable se both for fur and meat. The moose (*Alce americana*) is, howeve large game most pursued, as every part of the animal is convert the Indian to some special purpose of utility. The caribou (*Ra caribou*) ranks probably next in esteem of the hunter and In Besides these, the sly fox (*Vulpes vulgaris*) sometimes fails to observation; while the fisher (*Mustela pennantii*), the beaver (*C fiber*), the otter (*Lutra canadensis*) and the mink (*Putorius* supply evidences of their occupation of the country, though se seen. The muskrat (*Fiber zibethicus*), on the contrary, is every present, and does not always take alarm with such promptness escape observation. By far the most abundant of all the quadru and most accessible to approach, is the squirrel of the country (*rus hudsonius*, but broadly white underneath), whose peculiar and characteristic chattering is heard everywhere, as he sits on a li a log, dissecting the cone of the pine or white cedar for the extr of the nuts. But the chipmuck (*Tamias striatus*) is also some abundant, and often ventures rashly into the midst of the ca gather up the crumbs from the explorer's repast. Equally u scious of danger, a little field-mouse sometimes ventures ne share with the chipmuck the waste of the camp. A jumping is also rarely seen. The wolf (*Canis lupus*) and the weasel or e (*Putorius erminius*) complete the list of quadrupeds which have under the observation of members of our party. The former cessively shy, but the soft-furred and handsome brown weas trudes sometimes into the camp, and roguishly steals and bears such bits of meat as suit its palate, if left exposed to the plun The writer has seen a bat occasionally, having the size and a ance of the New York bat (*Atalapha noveboracensis*).

The partridge is quite abundant, and supplies to the hunter a delicate and savory article of food. Wild ducks, in the season equally abundant and equally sought. Hawks and eagles often scream from their high flights overhead; and loons, as they float past, rend the air with their unearthly vocalization. Crows and gulls are few. The robin is common, but lacks the strong utterance of the southern representative of the species. The blue-jay scolds fiercely from his dried tree trunk, and the interesting Canada jay practices the tricks of a thief about the camp. The flicker screams from his high hole, and smaller woodpeckers enlarge the representation of their family. The white-throated sparrow sings mournfully and with monotonous sweetness during July, and loses his voice in August. Some creepers and sparrows diversify somewhat the avifauna of the region. But, on the whole, the birds are not numerous. Reptiles are still more infrequent. I have seen a small turtle (apparently a *Chrysemys*), and an occasional garter snake (*Eutænia*). Once I saw for an instant a livid-dark salamander, with red-striped tail, which immediately disappeared among stones; but among Amphibians, the green frog (*Rana fontinalis*) and shad-frog (*Rana halecina*) are common representatives. I once met on a hill, seventy-five feet above the Pigeon river and a quarter of a mile back, a frog acting like the land frog, but marked like the common shad-frog of the pools.

Fishes appear to exist in moderate abundance, but the pickerel and black bass are the only ones which our trolling-hooks have brought to the surface. Small fry are occasionally seen, but their scarcity would imply the lack of any abundance of other species than those named.

6.—*Climate.* Of the winter climate I know nothing from observation. The summer climate is agreeable. During two seasons, sunny days have been the rule. In the former season, violent thunder showers occured frequently, and, for the greater part, during the night. In the latter season, very few showers fell, and the weather became dry. I noticed in both seasons, a little tendency in August and September, to settled cloudiness and drizzling rains. Two or three times during the past season, the weather displayed truly alpine characters; and this I attribute to the considerable elevation attained in the region between the sources of the Boundary and the Pigeon rivers. The clouds floated near the earth and enveloped us in a chilling mist. Sometimes this experience lasted for half a day; but sometimes, only during the passage of a stray cloud. During days at a time, squalls of fine rain could be seen between us and distant hills, almost continually.

The hours of sunlight, in July and August, are intensely hot—especially in the sun's rays; but the declining sun is accompanied by a marked change in the temperature of the atmosphere; and the nights are always cool—generally cold. In such a temperature, the surface of the warm lake steams, and often saturates the air with a morning fog. The frosts, of course, appear early in the autumn; and signs of snow may be seen in the middle of September. With frosty nights and some hard freezing, the weather continues fine till late in October. On the whole, the summer climate is decidedly agreeable.

7.—*Method of operation.* The observations have been restricted chiefly to the lake shores; but the intention has been to identify, and if necessary, study, the rock at every outcrop. In most cases, a landing was made; but sometimes an inspection and hammer-test from the canoe has been sufficient. Rarely, in a region of uniform character, an examination at every eight of a mile has been deemed sufficient. Many times, of course, excursions were made inland from a quarter of a mile to two miles. This has been done especially where the geology of some eminence seemed to be an important object of research. Thus, in connection with the necessary portages, a considerable knowledge of the country intervening between the lakes has been obtained.

All notes of facts observed were made in the field and on the spot; but frequently, generalizations were written out in camp, when a particular section of work had been completed, and while the facts remained in memory, even in greater detail than could be recorded in the notes.

8.—*Plan of the report.* The general plan is similar to that of last year. The first part, after an abbreviated statement of the most important observations and results obtained outside of the state, consists chiefly of a somewhat full detail of facts observed in Minnesota, with particular designations of localities. This, it needs not be said, results in a presentation of little interest to the general reader; but it forms a repository of precise facts for the student and investigator, and serves to place him, as far as possible, in the position of an original observer, with the means of putting his own interpretation upon the geology of the region. The other course—I may say the usual course, supplies the reader with a connected readable account; but it is simply the writer's individual conception of the facts and their meaning, and furnishes the reader with little means of judging for himself of the soundness of the writer's conclusions. It is a method which places the judgment of the reader at the disposal of the author until the latter's opportunity for work in the same field, or for access to an exact statement of facts, enables him to exercise an independent judgment. It is a method which, for a time, forestalls criticism and establishes the writer's conclusions in the opinions of his contemporaries; and this may by some be considered an advantage. There are many occasions where the writer's interpretation of the facts is all that is expected or proper; but I think the geologist or the citizen who well considers the question, will admit that the whole body of facts accumulated by the State at considerable expense, and already on record in note-books, ought to be made accessible to every citizen interested; and that the annual report of work done is the proper receptacle for such facts.

But the writer would regard it as extremely unwise to leave an annual report restricted to an undigested statement of details. The general reader requires a digested and systematized account of the meaning of the facts; and the person who accumulated them stands in a more favorable position than any mere reader to supply such account. Accordingly, the second part of the present report is a statement of the observer's own conception of the meaning of the facts observed. This part *only* is addressed to the general reader. Perhaps this part should have been placed first, and the details on which it is based, afterward. But I see no adequate reason for disregarding the logical order, which ranges facts first and their interpretation later.

The work of the past season has completed a careful reconnoissance of the northeastern part of the state by the present writer. He is now in position to join the facts collected in 1886 with those collected in 1887, and attain to a somewhat complete view of the geology of that most interesting region. He has, therefore, permitted himself to conclude the present report with a presentation of those general and taxonomic conclusions which have been suggested by the writer's personal investigations.

9.—*Localities and rock numbers.* As heretofore, the writer has endeavored to ascertain the precise locality of every observation recorded; and this of necessity has been indicated in the report. It would obviate the chippy and perhaps unpleasant appearance of the first part of the report to omit citation of precise localities or to weave them into paragraphs, and give this part more the appearance of a narrative. This has been well considered. But I feel confident that the specifications of facts in detail would be less accessible than under the arrangement which puts foremost, and in a uniform position, the definition of locality, and follows that by the statement of fact. In this part utility should take precedence of style.

The rock numbers are in continuation of the series begun last year. As these numbers have not been reported in complete consecutive order, a table is appended to this report, presenting in serial arrangement, the localities for both seasons, with references to the pages of the two reports on which they are described.

The order of succession of the work in this report, as in the last, is geographical. All the facts are clustered around the several lakes and the more considerable rivers. As it often happened that one shore of a lake was surveyed on an outward trip and the opposite shore on the return, it results that the consecutiveness of the rock numbers is broken between the two trips.

10.—*Bearings.* Magnetic bearings, for convenience, were taken in the field; but these are here corrected for the true meridian by the use of data recorded on the Government township plats.

11.—*Rock identifications.* These were preliminarily made in the field, but often under difficult circumstances, and always without adequate means for investigation. A few of the identifications for the present year have been revised in the laboratory, partly by microscopical and chemical methods, and a few laboratory notes have been appended to the field notes. But, manifestly, no thorough petrographical investigation could be accomplished in the time allowed for an annual report; nor indeed would such work be appropriate. It yet remains to subject the entire series of rock specimens to careful study, with a view to rectifying the nomenclature and establishing true correlations between the petrography and geognosy of northern Minnesota and other well investigated regions. This will be a work of no little magnitude.

In the use of terms I have followed nearly the same practice as in the report for 1886. This conforms substantially to the usage of German petrographers, and especially of Rosenbusch in the new edition of his "Massige Gesteine." So far as my practice diverges from the German standard, it is chiefly in the use of a few words, and this circumstance will not in the least embarrass the intelligent reader.

12.—*Earlier observations and studies.* The belt of country along the international boundary was traversed by Dr. Douglas Houghton, in 1831, while travelling as physician and botanist to the Schoolcraft Expedition to the sources of the Mississippi river. Subsequently, while acting as geologist for the State of Michigan, he recalled the observations made and left a brief record in the introduction to one of his annual reports. "The route of the fur trade to the northwest," he says, "by way of Rainy Lakes, Lake of the Woods and Lake Winnepic was formerly carried on by passing over these hills [north of lake Superior] from a point a few miles west of the mouth of Pigeon river [Grand Portage settlement]. The trail or portage path passes over a low portion of the range and finally falls upon Pigeon river,[*] which is ascended to its source, from which, by a series of portages, the sources of the streams flowing northwesterly are reached. The hilly portion of the country, though of exceeding interest in a geological point of view, is the most desolate that could be conceived."[†]

During the progress of the geological survey of the Northwest, under the direction of Dr. D. D. Owen, a rapid reconnoissance was made by Dr. Norwood, from Pigeon point and the locality now known as Grand Marais, to Gunflint and Saganaga lakes. Beyond the latter point, no observations along the boundary are recorded.[‡] Dr. Norwood's notes are lacking in precision and intelligibility. It is often impossible to identify his localities or his facts.

A rapid reconnoissance along the international boundary was made in 1872 by Mr. Robert Bell, under instructions from the Geological Survey of Canada.[§] The facts recorded, however, are few, as the chief object of the expedition seemed to be an exploration of the country further northwest.

In 1878, professor N. H. Winchell, in a survey of the mining geology of the northwestern part of Minnesota, visited numerous localities near the boundary, both in Minnesota and Canada, and traversed the boundary from Pigeon point to Basswood lake, proceeding thence to Vermilion lake.[||]

A more extended reconnoissance was made by N. H. Winchell, in 1880,[¶] stretching from Grand Portage along the international boundary, and diverging to Vermilion lake, and thence to Squagamaw bridge on sec. 5, T. 58-15. This was part of a very extensive examination of the general geology of the northeastern part of the state. The report presents a broad and masterly, though condensed, grasp of the geologic structure of a vast region long acknowledged difficult of access, complicated and obscure; and the later developments have confirmed its general accuracy.

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[*] For quite a full description of the physical and geological features of this trail, see N. W. Winchell, *Eighth Annual Report*, *Geology of Minnesota*, 1880, pp. 71-73.

[†] Houghton, *Fourth Annual Report*, *Geology of Michigan*, 1811, p. 13.

[‡] Norwood, in Owen's *Geological Survey of Wisconsin, Iowa and Minnesota*, Philadelphia, 1852, 405-433.

[§] R Bell, in *Geological Survey of Canada*. Report of Progress, 1872-3, Montreal, 8vo, pp. 92-94.

[||] *Seventh Annual Report*, *Geology of Minnesota*, pp. 9-25. This report contains also, *some observations* by C. W. Hall, under instructions from the state geologist, pp. 26-29,

[¶] *Ninth Annual Report*, *Geology of Minnesota*, pp. 71-107. This contains a general descriptive list of rocks collected in 1878 as well as 1880, extending over pages 11-114.

Explorations of the geology of northeastern Minnesota were further extended by N. H. Winchell, in 1881. They were carried over the Grand Marais trail, and along the boundary westward, but more extensively across the country wholly unknown to geology, west of the Grand Marais trail, between the boundary and lake Superior[*] and as far west as Ogiskhe-muncie lake.

In the operation of the United States Geological Survey, the study and discussion of the Archæan rocks of the Northwest having been assigned to professor R. D. Irving, geological observations made by himself and under his direction, have been extended from Nipigon and Thunder bay of lake Superior, into Minnesota, as far as Gunflint and Ogishke-muncie lakes. The particulars of these explorations have not yet been published; but some of the general and most important results have been made public from time to time, in memoirs and papers by professor Irving.[†] Professor Irving's investigations, sustained by the great resources of the national survey, and carried on with the aid of much experience and excellent preparations, may be expected to bring to light a vast multitude of facts, and to go far toward settling the difficult and fundamental questions now outstanding in reference to the geological character and history of our oldest terranes.[‡]

The State survey of Minnesota resumed, in 1886, the investigation of the rocks northwest of lake Superior, and made this a principal effort during the year. The region of Vermilion lake was minutely studied. The country eastward was explored as far as Ogishke-muncie lake, and the geology along the boundary belt was examined from Iron lake to Knife lake. The volume of results exceeded all previously published.[§]

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[*] *Tenth Annual Report, Geology of Minnesota*, 1881, pp. 64-106. Geological notes from Duluth to Silver islet and return, are contained on pp 34-64.

[†] See *Third annual Report, U. S Geol. Surv.*, 1881-82 (dated 1883), pp. 157-165. *Monograph. U. S. Geol. Surv.*, vol. v. (1883) pp. 367-386, 395; *Preliminary Paper on an Investigation of the Archæan Formations of the Northwestern States*, March, 1886. extracted from Vth Ann. Rep., U. S. Geol. Surv., 175-242 (especially pp. 203-208): *Amer. Jour. Sci.*, III, xxxiv, 259-363.

[‡] While the manuscript of this report is still in hand, tidings come of professor Irving's death. I feel moved to embrace the opportunity to record both my personal sorrow, and the loss, seemingly irreparable, which has been sustained by the national survey, and by the interests of geological science at large. Professor Irving's work revealed a most conscientious, painstaking and intelligent treatment of the difficult problems assigned to him for discussion. His achievements in a few years, alas too few, have contributed permanent lustre to the annals of American science.

[§] *Fifteenth Annual Report. Geol. Surv Minn.*, 1885, pp. 7-207 by A. Winchell; pp. 209-382 (embodying observations by Dr. M. E. Wadsworth) by N. H. Winchell; and pp. 401-419 by H. V. Winchell. This report contains the first colored geological map of northeastern Minnesota made from original observations, and a detailed geological map of the vicinity of Vermilion lake.

§ 2—OBSERVATIONS IN THE TYPICAL HURONIAN REGION OF CANADA.

A portion of the rocks of northeastern Minnesota have been provisionally referred by recent geologists, to the Huronian system. The most recent writer on the assemblage of oldest formations in the Northwest, expressed the conviction that the entire series of strata in Minnesota, from the top of the crystalline schists up to the top of the Animike slates, belonged properly in that system which, a quarter of a century ago, the geologists of the Canadian survey described and named as Huronian. The region reported to contain the rocks thus assembled in a system, lies on the north of lake Huron. Being somewhat remote, if not difficult of access, American, and even Canadian, geologists, have been in disagreement as to the lithological character of the original so-called Huronian rocks, and as to the position which they actually hold in the bedded structure of the earth's crust. An ulterior purpose of the Minnesota survey must be. First—To ascertain whether any proper Huronian rocks occur in the state; Second—To determine what portion of them is to be regarded as Huronian, and in what particulars they agree, and in what those distinguished from them disagree; Third—To determine the relative geological age, both of the rocks ascertained to be Huronian, and of those to be excluded from the Huronian. But precisely what was meant by Huronian was a point in dispute; and any settlement of the question in time for the purposes of the Minnesota survey, required a personal visit to the typical Huronian region. In conformity with this necessity, my brother and I made a personal investigation of most of the important points and districts within the region referred to. The following pages contain an abstract of observations made by the writer, with such occasional interpretations as, to his judgment, seemed justified by what we saw.

The quartzytes exposed along the north shore of the channel, between the Sault and the old Bruce mines, were hastily passed; and no careful studies were undertaken until "the Bruce" was reached.

1. *Observations about the Bruce mines.* At the old Bruce mines the rock near the shore (384)* is a mass of diabase, intersected in various directions by joints, but without discoverable signs of bedding. It is a compact mixture of a dark, augite-looking mineral with a reddish feldspar. The dark mineral constitutes a sort of groundmass; but the feldspar is very abundant. In places, the red feldspar occurs in crystalline masses an inch or two in diameter.

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*The numbers in this section refer to the rocks collected.

Near the gravel bank made from the crushing mill on the east si
the diabase (385) is a little coarser, and the feldspathic constituent
nearly white. In the midst of the rock are masses of a fine-grai
material which, at a glance, appears slaty, but, on inspection, se
to be a very similar thing in constitution. These fine masses
partly vein-like, and partly like regular fragments of a schistose r

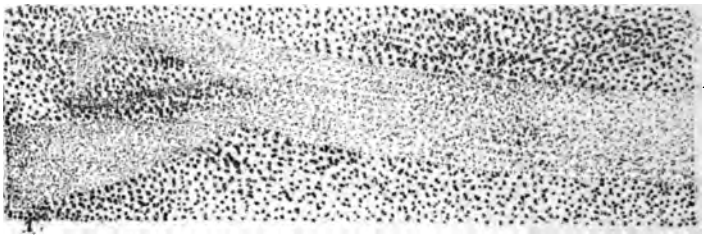

Fig. 1.—*Vein-like mass in diabase at Bruce mines, Ontario*

Whatever the nature of these forms, the whole mass of rock, se
to be a dike in the other diabase. If these different diabases are
dikes successive in origin, they show abrupt limitations dike-like.
me the whole mass looks like a vast dike or overflow; but the diffe
parts are supplied from somewhat different sources, and cooled u
circumstances a little different.

In one place I find diabase with disseminated globules of serpent

At the Glanville shaft of the Wellington mine, the vein is
running N. 82° W. It is of quartz with dissiminated chalcopy
The country rock resembles the diabase with red feldspar; but
the quartzyte it becomes slaty-chloritic.

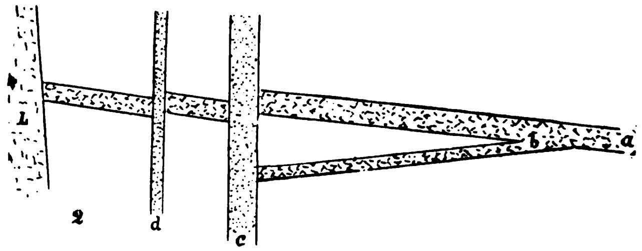

Fig. 2.—*Plan of cupriferous veins at old Wellington mines, Ont*

The main vein *a*, branched in *b*, was cut by a dike at *c*, and ran
a limestone at *L*.

Mining was carried on 35 years and has been suspended 10—in
sequence of ore running poor and copper cheap.

About a quarter of a mile west of this is an outcrop of limestone in a ledge trending N. 4° W. and dipping a little south of west, but much contorted, and with interbeddings of trap isolated from the general mass of trap. This outcrop in a straight line, is about a mile from the west landing.

From the little cove immediately east of the old Bruce mines rises toward the west, a hill on which lie an enormous quantity of "greenstone" fragments. Where the greenstone outcrops, it is a compact diorite or diabase. In this is a quartz vein striking N. 6° E. and two feet wide. The entire mass of the hill is of the same sort of rock, and on the summit and the western slope are large quartz veins which ramify in a complicated fashion. In one place, a quartz vein intersecting the country diabase, itself incloses a large fragment of diabase, as shown below:

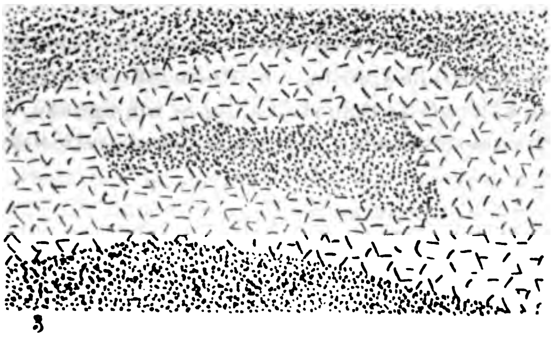

Fig. 3.—*Fragment of diabase included in a quartz vein intersecting a field of diabase near the old Bruce mines, Ontario.*

Among the bowlders of this vicinity I recognized bedded and conglomeritic quartzyte and jaspery conglomerate; also a conglomerate resembling that of Ogishke-muncie—a dark, diabasic groundmass with red granite pebbles.*

The diabase surfaces are glacially smoothed, and show grooves trending S. 20° W.

2. *Observations in the Valley of Thessalon river.*—At Thessalon, on the west side of the river, the rock (389–391) which is put down by Logan as "chlorite slate," has superficially an eruptive look. Occasionally one sees evidences of bedding, though obscure. The dip appears to be 37°, in the direction N. 41° W. The rock is fine-grained,

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* A list of the rock-collections will be included in proper numerical order in the Table at the end of this report.

dark, hard, having the aspect of a metamorphic argillyte; but on close inspection with a lens, thin scales possess a waxy, greenish translucency. So far it might be a highly metamorphic felsitic argillyte.

A few rods to the east of this, however, the formation passes into a diabasic rock similar to that carrying the copper vein at Bruce. As no probability exists that this is of an eruptive character, and the other rock sedimentary, I examined the transition carefully. The strong impression made by the study was that the case is simply one of greater or less metamorphism.

This diabasic or dioritic condition is seen coarser and finer exactly as at Bruce. Here also, are numerous ramifying quartz veins. If this formation is an altered sediment, so is that at Bruce.

Several times subsequently I revisited this locality—on the west of the river—after having made quite an extended study of the surrounding country. I repeated my attempts to ascertain the nature of the bedded structure. I could not easily divest myself of the impression that a true sedimentary arrangement had originally existed, on which, in the course of metamorphism, a conformable slatiness had been induced. The evidence, unquestionably, is ambiguous, but I retained two small specimens showing distinct marks of sedimentary character. This structure prevails in patches over an area of forty square rods. The dip, according to renewed measurements, is 32°, in a direction N. 48° W. Naturally, it varies in both respects within short distances; but though the bedding is undulating, it is not crumpled.

In the midst of the most slaty patches occur more diabasic portions; and generally in proximity to small veined streaks—as if greater heat and more complete fluidity had been the condition of the more diabasic rock.

There are indeed, places a square rod in extent, in which the rock is strictly diabasic; and it here appears that the coarser condition of the diabase is most remote from the slaty rock.

This particular spot is a fair representation of the whole of Logan's "green chlorite slate." While no demonstrative evidence exists of the nature of its genesis, there seems to be room for the supposition that the entire formation was once a marine sediment; but if so, it has been subjected to powerful alteration—in places, to actual fusion and recompounding of the chemical elements.

On the east side of the river, the same formation (392) prevails extensively. The bedded condition is more unmistakable than on the west side. The strike of the beds is nearly coincident with the direction of the glacial striation, which is S. 20° W. There is difficulty in deciding what are the bedding structures and what schistosity or veins. Near the water the bedding appears most unmistakable.

But another phenomenon here is important. Along some of the vein-like appearances are rounded pebbles imbedded in a mass similar to the neighboring rock, but darker and distinguishable in texture. The rounded pebbles are of rock similar to the prevailing formation; and on close inspection, lines can be traced across them—fine, like flowage lines or thin laminæ. The appearance is precisely like some conditions of the Ogishke formation—not the characteristic conglomerate.

At the north end of the village near the head of the bay east of the saw mill, the same formation (393) contains large angular masses of epidote, mixed with a black mineral. These masses are up to three feet in length, with a width of two. Here are also, veins of quartz, some containing chalcopyrite, and some having a selvage of fine, dark chloritic mineral.

Quite at the head of the bay east of Thessalon, the following observations were made: 1. Regions containing many little blaekish lumps, giving the rock an amygdaloidal appearance (394). The lumps look like amorphous chlorite externally. When scratched they are bluish, slaty-white. 2. These quasi-amygdules are in places arranged in courses. Sometimes the courses are rectilinear, and sometimes curvilinear; and in both cases, several ranges are parallel with each other. But in immediate contiguity, the curved bands are seen in a different positition. This phenomenon reminds me of what I have figured from the east end of Snowbank lake, Minnesota*; but in that case the amygdular cavities are in single series, and the apertures are sharply circular. 3. In some places, larger lumps of this chlorite-like mineral are remotely disseminated, Also, some of these larger cavities are filled with epidote—either finely crystalline or mixed with another mineral. 4. The formation is also intersected by veins of calcite or dolomite. 5. Also by veins of a red color, composed of a transparent mineral like calcite, and a pale reddish mineral, having, like the other, the hardness of calcite. 6 Bands also, of small epidotic amygdules—some in belts one and a half inches wide and separated by a condition of the country rock—a soft chloritic argillyte, itself filled with very small elongated amygdules of amorphous chlorite—the longer axes parallel with the axis of the band. 7. In the vicinity, some of the chloritic amygdules are elongated downward, from one diameter to three and a half inches—in section of the rock looking like rootlets of *Stigmaria.*

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* *Fifteenth Ann. Rep Geol. Surv. Minn.*, p 129.

At the head of the bay east of Thessalon, near the new barn are seen two sets of glacial striæ in unusual relation to each other The main set trends S. 20° W. and the other S. 48° W. The former are grooved; the latter smoother. The main system terminates abruptly along the line *ab.* fig. 4., and that line is like the ridge of a low roof.

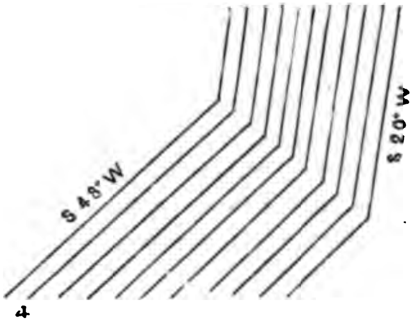


Fig. 4.—*Unusual feature of glacial striation, Thessalon, Ontario.*

Further along is a similar crest without change in direction of striæ

After quite an extensive and careful field investigation of the formation about Thessalon, I failed to find any sufficient reason for distinguishing it from that about Bruce; though Sir William Logan has laid it down as "green chlorite slate" while the Bruce formation is mapped as "lower slate conglomerate." It is more slaty on the east side of the Thessalon river than on the west. Still it can hardly be said that the evidence is clear. The resemblance to the Bruce formation is general; but only on the west side does it seem complete. Here the diabase is fully developed, and we trace it by gradation into the slates. But on the other hand, quartz veins are common on both sides of the river, and they contain chalcopyrite. On the east side of the bay a vein is said to be four feet thick, and to have been worked to a limited extent. In all salient characters, the Bruce and Thessalon formations are the same. I must leave for future study to ascertain whether in origin it is rather sedimentary or eruptive.

About one and a half miles from Thessalon landing, on the Government road west of the river, is an outcrop of quartzyte (395). It rises in a range west of the the highway. Near the road it is light gray and pretty fine, with distinct bedding and a northward dip of about 35°, but somewhat contorted. Farther from the road it becomes darker and more granular (396). A few rods still farther west, the formation rises in a succession of short parallel swells trending east and west, and exposing a general dip northward. The appearance is shown in fig. 5, on plate 2.

We find dark angular masses (397), included in the quartzyte; and inspection shows them to be essentially identical with the Thessalon slate; but even more baked.

Still farther on, occurs a dike three rods wide, running nearly north and south, and appearing to be a compact diabase (398). In contiguity with this, the quartzyte is red blotchy, and on the west, prevailingly red (399). Included in the dike is a wedge of quartzyte, two rods long and fifteen feet wide, which is very red. Here the dike along its western margin, is divided vertically by jointage, into a succession of thin slabs. Close by, the quartzyte retains its proper bedding.

Sometimes too, the bedding of the quartzyte is interrupted by dike-like masses of its own substance, which, with loss of stratification on their part, cut off and terminate the beds of the main quartzyte.

About two and a half miles from Thessalon, along the same road, on the northwest of the quartzyte, is seen rising a huge diabasic mass (400), resembling the diabasic portions seen on the west side of the river at Thessalon. From the summit, I can trace the ridge to the quartzyte last seen, and beyond, along the west side of it toward Thessalon point. Possibly the point has this diabase for a foundation.

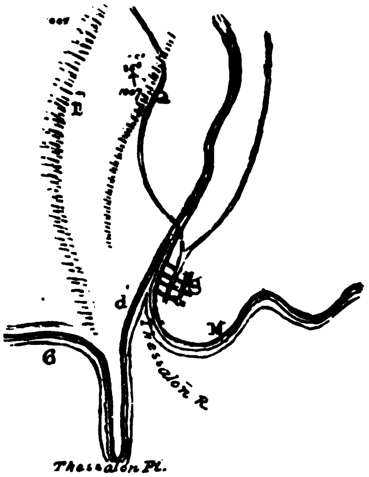


Fig. 6.—*Geology about Thessalon, Ontario.*

D, the diabase here referred to. *Q*, the quartzyte 395. *P*, Thessalon point. *M*, the sawmill near the landing. *d*, diabase west side of river, *s*, Thessalon slate (or slaty diabase).

Queries. Is there a fault along the river? Does *D* underlie and form the point? Are *D* and *d* the same as *s*?

About three miles from Thessalon, on the same road, a bold promontory strikes the highway. Of this all the upper portion is of diabase (402), and the lower, near the road, is of quartzyte (401).

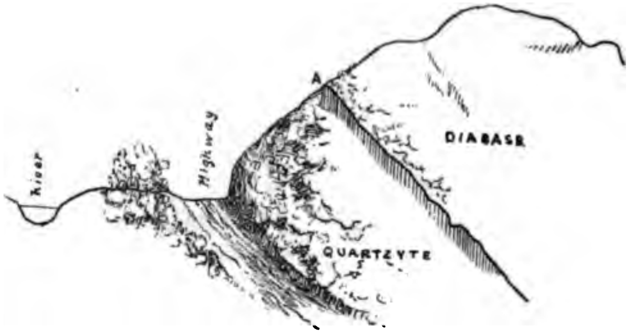


Fig. 7.—*Junction of quartzyte and diabase three miles northwest of Thessalon, Ontario.*

The line *AB* shows the junction of the two, and its direction is east and west. But the plane of junction descends almost vertically into the hill, so that it is not possible to say the diabase overlies the quartzyte. The diabase is in continuity with the last seen.

At about five and a half miles from Thessalon, another promontory is found abutting on the road from the right. Here the great mass is diabase (403), well characterized and moderately coarse-grained; but quartzyte is in contact in an unintelligible way. The face of the exposure is shown below:

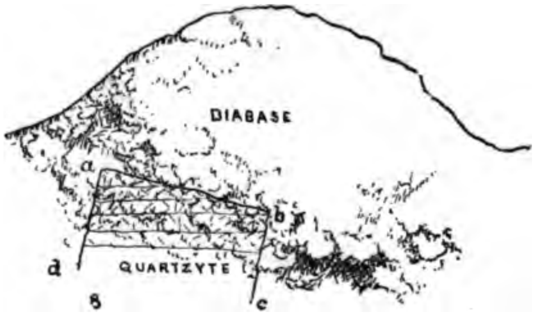
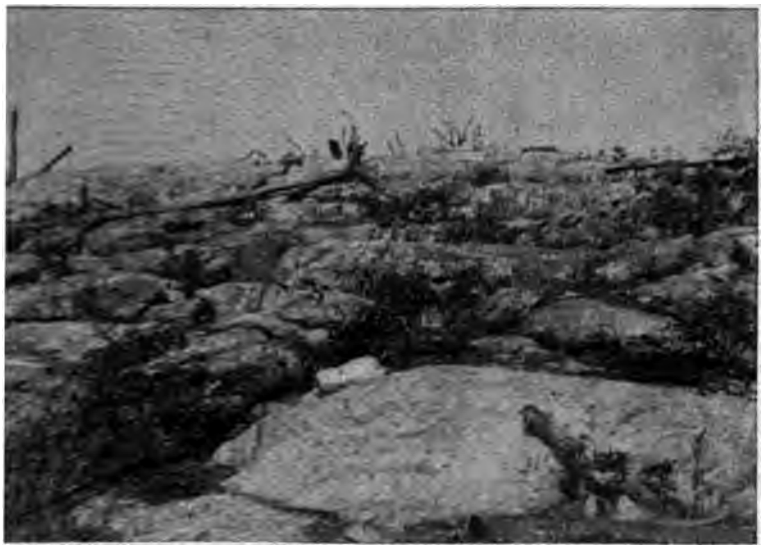


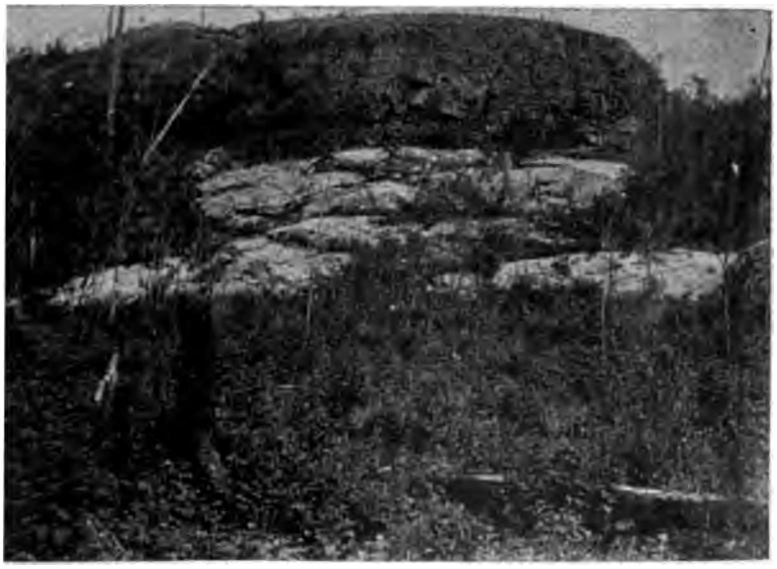
Fig. 8.—*Junction of quartzyte and diabase five miles northwest of Thessalon.*

Plate 2. 16th Report.



g. 5.—*General view of white quartzyte, two miles northwest of Thessalon, Ontario.*

The dip is away from the observer.



10.—*A knob of diabase overlying quartzyte four miles northwest of Thessalon.*

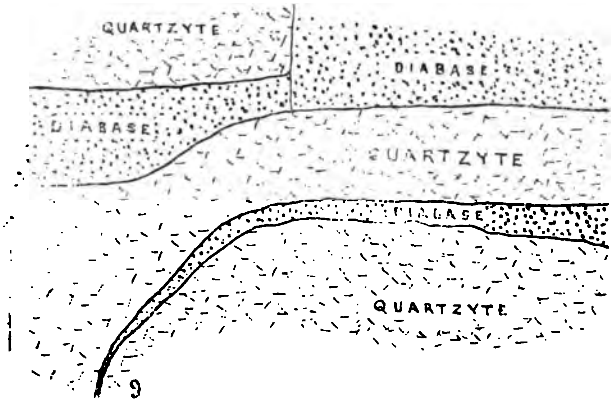
The quartzyte incloses *angular masses of* Thessalon slate.

om *a* to *b*, the quartzyte dips toward the diabase, and seems to go r it northward. From *b* to *c*, the diabase cuts off the quartzyte ı dike. Hence it does not appear what is the relation between the The quartzyte is cut off also from *a* to *d*.

e diabase is quite characteristic, consisting of a mass of crystal· black, augitic mineral, with short linear crystals of plagioclase lded in it.

miles from Thessalon, where McBeth's creek is crossed by the la Pacific railway, in view of the lake, quartzyte and diabase en in contact again. The junction is sharp and runs N. 60° W. uartzyte is light gray, and resembles 401—not so reddish as that base of 403. Some of the diabase is rather coarse and charac· . The junction with the quartzyte is vertical again—neither is mposed.

ss the creek from this point, and on the north of the Canada railroad, is a hill composed of quartzyte (404) and diabase; portion of the quartzyte becomes conglomeritic with glassy . One of the dikes of diabase pursues an irregular course, as below, and varies greatly in width—from thirty feet to zero. al collocations of quartzyte and diabase are further illustrated



.—*Map of alternations of quartzyte and diabase on hillside at McBeth's creek, at crossing of Canada Pacific railroad, northwest of Thessalon.*

ıbout four miles from Thessalon, a high boss overlooks the road the south, in which we find diabase distinctly resting on quart· The external aspect of this exposure is shown in fig. 10, plate 2.

At the distance of one mile from Thessalon on the east side of the river, is another nearly vertical junction of diabase and quartzyte, striking N. 40° E. The junction is sharp. No dip of the quartzyte is ascertainable. Its color is pale pinkish. Near here the quartzyte dips 30° toward N. 40° W. and its color is still pinkish. At another point the color is white.

At two miles from Thessalon on the east side of the river, is an outcrop of quartzyte (405), weathering pistachio greenish, fine-grained and saccharoidal. It includes masses of coarse pinkish quartzyte containing quartz pebbles. Apparently, this quartzyte would make good hones.

Quartzyte knobs rise above the alluvial plain at frequent intervals.

At Little Rapids of the Little Thessalon, three and a half miles from Thessalon, is a coarse diabase with veins of quartz. It rises in a knob which continues in a range eastward. It appears also on the west of the road. Near by here, is a vitreous quartzyte with pebbles of black jasper arranged in courses. The direction of the dip is N. 10° E. and amount apparently about 45°. This spot is one-fouth mile from the hotel, and in stratigraphical order ought to overlie the rock at Little Rapids.

At about four miles north-northeast from Thessalon, is a boss of well striated quartzyte, having one set S. 20° W. and the other S. 30° W. The quartzyte is granular, pale gray, homogeneous, and would make excellent hones—much resembling that of 405. In places it consists of clear glassy grains imbedded in a groundmass.

A knob of very fine diabase forms a ridge extending north and south, at a distance of about three miles northeast of Thessalon.

Extending examinations to remoter points, we find, a quarter of a mile north of Little Rapids, a knoll of horizontally-bedded, very fine sand—evidently alluvial.

On the west side of the Little Thessalon, and about three-fourths of a mile from Ansonia—familiarly known as "The Dump," on the north of the road, is a ridge, exposing much red rock (406), which proves to be a red quartzyte, with pebbles of clear quartz, and some small red jasper pebbles. It is virtually a conglomerate. This ridge ranges N. 70° W. and attains an elevation of about 150 feet. With much labor I traversed the whole length of this forest and brush-covered ridge, and noted a succession of formations like the following. Passing from the condition just mentioned, we come to conglomerate. Then comes a dike of diabase (407), 100 feet wide, extending from top to bottom of the hill. Next recurs conglomerate, coarser than the first, with white quartz pebbles. This is followed by another dike of diabase, 40 feet wide, cutting the hill, like the other, from north to south. Next follows for 30 rods, a conglomeritic quartzyte. This is a bold outcrop. The bedding is distinctly shown by great slabs two feet thick, and by courses of pebbles. The dip is 30°, and direction S. 48° W. This continues to another bold outcrop of quartzyte. which is fundamentally very red and vitreous, with small pebbles. The bedding is shown by slabby structure and by dark streaks—almost black, as if of magnetite or plumbago. Oblique lamination is also present, and the strata are a little bent

This entire ridge is a little over half a mile long. Diabase appears at the base, and can be seen on the summit; and the appearance is that a dike runs along the crest, and this has tilted the quartzytes to their present position.

The quartzyte beds dip 42° in a direction making an angle of 20° with the axis of the ridge. As the ridge was traced for a distance of about two and a quarter miles, we thus attain the data for calculating trigonometrically, the vertical thickness of the whole quartzyte formation. I thus find it to be 4,542 feet. As the horizontal distance was merely estimated, no great exactitude can be ascribed to this result. As further. I have no evidence that this traverse crossed the whole width of the formation, it would be quite within the bounds of probability to set down the red quartzyte as having a thickness of 5,000 feet.

At Ansonia Post-office (411), are rapids in the Thessalon river, and here the saw-logs from the surrounding country are "dumped" to be rafted to Thessalon. The rapids are caused by a mass of bluish, fine, compact diabase, but the geology of the place is obscure. After visiting the spot three times during the progress of our survey of the Huronian, the following is the best account I can give of it. Beginning up the stream, we have first, a mass of fine blue diabase (448); then alongside of this, some vertical standing, ashes-of-roses colored, cherty-calcitic beds (449), running up from the water. This formation weathers ochreous-yellow. Within, some parts are fine, compact, chalcedonic-looking, opaque; other parts are pinkish, very finely granular (450), and closely resembling the rock 447, to which refer. Still another part is less homogeneous, with iron-oxide veins, and a little coarser texture. Still below this occurs a diabasic slate (451) in a thoroughly brecciated condition. A bowlder from the ochreous mass was found by me at Bruce. It seems to correspond to Logan's "chert and limestone." It is a cherty limestone (452), and effervesces feebly with acid, but its stratigraphical position is not made apparent from the concomitant facts.

Half a mile south from Ansonia, the ridge studied at 408, but at a point a mile further south, presents characters similar to those already described. Some of the pebbles here are like the ochreous rock 409; and this would imply that this rock underlies the quartzyte—the red quartzyte.

On a later occasion these examinations were carried still farther into the interior. One mile beyond Ansonia, on the south side of the Thessalon (428-429), a knob on the right of the road is composed of speckled diabase. A vein of red feldspar runs through it, and many patches of the same occur.

Two miles west of Ansonia, on the north side of the road, in the field and on the hillsides, are large detached masses of reddish quartzyte, with bands of pebbles as south of Ansonia. Also of red jaspery conglomerate.

Some two and a half miles west of Ansonia, in the S. W. ¼ sec. 8 Lefroy, on the right of the road, is a low smooth outcrop of fine-grained rock (430), appearing like schist standing nearly on edge, and traversed by many rough, irregular quartz veins. The rock on weathering peroxidizes a considerable amount of iron, forming a rusty crust. The rock is excessively tough, and thin scales are pale, yellowish-green translucent.

The strike of the structure referred to is N. 75° E. and the dip 30° to 40°. The formation is intersected by metalliferous veins. The contained matter is crystalline, black, with red streak.

Two and a half miles east of Ottertail lake, about S. E. ¼ sec 31 Rose, is a white vitreous quartzyte, having a dip S. 53° W. amounting to 23°. Within limited areas it is purple; but the purple portions are chiefly related to a vein and jointed system trending S. 80° E. There are also spots purple-colored, consisting of hematite in the ntre.

Near the southeast end of Ottertail lake, is a lofty ledge of quartzyte of a gray color, and dipping southwesterly. This is on the left of the road leading from the village of Ottertail north to Duff's valley.

Ottertail village is at the southern corner of Ottertail lake, in the township of Plummer and on the south side of the stream. Twenty rods south of the four corners is a prominent outcrop of a reddish rock (435), which on inspection is seen to have a southwesterly dip, and is therefore conformable with the prevailing quartzyte of the region. It is not however, a proper quartzyte. It undergoes change on exposure to the weather. It has not the lustre of quartzyte. It is compact and has a large feldspathic constituent. It seems to be a real felsyte, but clearly not an erupted felsyte. Much of the formation is thin-layered, and it may properly be designated a felsitic schist.

On the east side these beds can be seen dipping S. 58° W. at an angle of 20°. Here also is a dark, slaty, fissile, somewhat soft trap-slate in an irregular seam striking across the bedding of the formation.

Twenty rods west and at a higher altitude, the felsyte again outcrops: but the dip here is only 12°, and in a direction N. 10° E.

The prevailing dips in this region have been found toward the southwest. From this point, a ridge of white quartzyte can be seen on the northeast at the distance of half or three-quarters of a mile, on the north side of the river, in which the dip is directly toward this felsyte. Unless some great disturbance in the order of stratification exists, the place of the felsyte is above the quartzyte. This ridge of quartzyte is shining white and though it attains an altitude of one or two hundred feet, a dip of twenty degrees would carry the top of it quite below the felsyte.

Thirty rods still further west, and about half a mile in a straight line from Ottertail four corners, rises a conspicuous bluff twenty feet high, composed essentially of felsyte of red color (434). It has a dip of 30°, in a direction N. 20° E. Here can be seen convincing evidence of transition between quartzyte and this felsyte. Not only is the sedimentary bedding everywhere observable, but here the red felsyte visibly passes into a dark gray flint rock just perceptibly tinged with ashes-of-roses color where unweathered, and red rusty as far as the weather has penetrated. Under the lens, the fresh rock seems to be about all fine amorphous quartz, with numerous glistening points, which really look like thin scales. There are also disseminated small grains of quartz. The rusted portion is a skeleton of quartz draped with limonitic oxide.

On the highest knob facing the village and 125 feet above it, the rock is an altered slaty conglomerate. The main mass is dark greenish earthy material, similar to the vein in 435, though not here in a vein—having obscure but unmistakable bedding, appearing brecciated in places, inclosing some well-defined angular pieces of the same; but specially noticeable for containing many worn masses of granulyte composed of white quartz and a larger proportion of white feldspar. This whole formation is therefore conglomeritic; and its position, in connection with the prevailing dips in the neighborhood, indicates that it is higher than the felsyte 435. But of this one cannot feel sure, since some of the dips in this vicinity lie in opposite directions.

In general, however, we may say that in the hill south of Ottertail, we have a mass of highly altered schists, which range from felsitic to quartzose and conglomeritic, with fine earthy slate for groundmass Their vertical relations to each other and to the quartzytes of the vicinity cannot be absolutely determined from evidences supplied by the neighborhood.

About half a mile from the place of 434 in a direction S. 70° E, rises another boss of felsitic slate with bedded structure about vertical, trending toward 434, but of the lithological character of the rock 435.

Twenty rods northwest of here, and about in a line parallel with the axis of Ottertail lake, and on the south of it, occurs an erupted mass of rock (437), weathering light gray with a tinge of green, and composed of pale greenish augite and lamellar labradorite. There are occasional rusty spots, but no iron constituent is conspicuous. The rock approaches a compact gabbro. Its position is also above the great white quartzyte of the Ottertail range, and perhaps below the slaty felsyte already described. It may however exist in the form of a dike and not of an overflow. The outburst traced northward a few rods is found terminating in a cliff 75 feet in perpendicular hight. Here the rock has a more diabasic aspect.

Down the Thessalon river, half a mile below the bridge at Ottertail, is found an outcrop of fine grained, well-bedded, somewhat fissile, cherty limestone (439), gray within, but weathering cream-colored. It dips S. 58° W. at an angle of 20°. It contains bands of pale reddish color, and bands of chert. It is a cherty limestone, and is reputed a lithographic stone. This, like the cherty limestone seen in the bed of the river at Ansonia, may represent Sir William Logan's "chert and limestone." This I will designate the Ottertail limestone.

This range of limestone trends conformably with the Ottertail quartzyte, and holds position above it, unless brought up from below by a fault. That its original position is below the quartzyte is indicated, as already stated, by the discovery in the quartzyte of pebbles which seem to have been derived from a rock of the kind.

Leaving this neigborhood and penetrating farther into the interior, we find that at two miles north from Ottertail, we have crossed a white quartzyte ridge about a mile wide, and also a mass of underlying red quartzyte about three-fourths of a mile and strike here a mass of noryte (440).

Four miles north of Ottertail, we pass another sharp hill formed of noryte-looking material which would perhaps pass for gabbro.

In the town of Plummer, two miles south of Murray's Corner, one and a half miles north of Orange Hall, and somewhat more than four miles north of Ottertail, on the west side of the road, is a high outcrop of metamorphic slates (441), mostly compact, with slatiness moderately well developed, but to a large extent a well characterized slaty argillyte, siliceous in places and inclosing bands of siliceous schist. It is impossible to possess any information respecting the Animike series, without recognizing that formation here. The dip is S. 20° W. at angle of 46°.

This formation clearly passes under both of the quartzytes—the white and the red.

It is now apparent that the rock 441 is also Animike slate.

Twelve rods northeast of this, and separated from it by a little valley, is an isolated outcrop whis is largely red felsyte (442), but is also largely an incipient granulyte—the red feldspar appearing in progress of separation from the quartzose constituent. This is fine-grained, and the quartz appears in small round globules. This transitional state between felsyte and granulyte has a petrographic significance analogous to that between felsyte and quartzyte as seen in 434.

It is worthy of note that the stratigraphical position of this felsyte, as will presently appear is a short distance below the summit of the Plummer argillyte—just as the felsyte at Ottertail appears to be superimposed by a similar slaty argillyte at the summit of the knob south of Ottertail.

Eight rods beyond, and close by the north and south road, a ridge of noryte (443), comes down from the west. It appears to contain magnetite, and may probably be regarded as a proper gabbro.

At Murray's Corner, 23½ miles from Thessalon, on the town line, one mile west of the northeast corner of Plummer, rises an enormous promontory of argillyte (444, 445), the greater mass of which extends over into the town of Coffin, sec. 36. It has the same character as 441; but the dip is much steeper—being southward 78°. It contains pebbles of red granulyte, of all sizes up to two feet in diameter It recalls somewhat the peripheral portions of the Oghiske conglomerate, but is somewhat more earthy.

From the top of the hill, which is probably 175 feet high, above the road, is revealed a wide outlook over the surrounding country. Close by is Rock lake, on the west. Beyond, rise high hills, with wavy outlined tops; and in the horizon, the country looks mountainous. In all directions, the region is hilly, broken and rough. The rock formation on the summit is hard and slaty, and contains red granulyte pebbles. The direction of the dip is S. 20° W.

The formation in the vicinity includes a bed of quartzyte in which occurs crystallized hæmatite in small branched veins.

On the "Soo" road, two miles southeast of Ottertail, is another outcrop of Plummer slates, very similar to 430 and 431. The slate is bluish-black, weathering greenish. The stratification is horizontal—an attitude which may indicate the passage to the opposite dip—that is, toward the northwest. The shale is fissile and intersected by many joints, which are frequently filled with brillant iron oxide. It includes a bed of red quartzyte, the faulting of which is illustrated below:

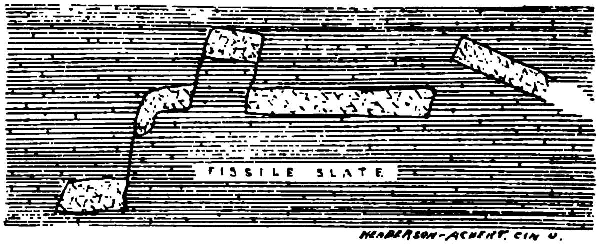


Fig. 11.—*Faulting of a red quartzyte bed, two miles southeast of Ottertail, Ontario.* In Huronian slates.

The slates have been faulted the same as the quartzyte; but that does not show.

The movements of this formation have opened chasms 6 to 12 inches wide, which have been filled mostly with a breccia of the country rock. It also contains rounded pebbles of red granulyte.

Within a distance of twelve rods of this place, on the east, is another outcrop of the same (446). It contains rounded pebbles of syenite with red feldspar, also great angular masses intersecting the formation but limited; having apparently a siliceous constitution, but without any quartzose lustre. On closest inspection with a lens, I can distinguish apparent particles of reddish feldspar, and many specks appearing like hæmatite or magnetite.

The quartzyte (447), seems to be very finely porous, and resembles that containing iron ore at Matherson's, near Murray's Corner. It serves to identify the lower division of the Plummer slate-conglomerate.

At about one and half miles north of Bruce, on the "Soo" road the slate conglomerate outcrops again. It contains red jasper pebbles and graywacke, and the formation is rather harder than at the last two points

From here eastward the slate conglomerate outcrops frequently—even as far eastward as McEwen's cross roads and school-house

3. *Observations in the vicinity of the Blind and Missisagui rivers.*—This investigation was also pursued in the vicinity of Blind and Missisagui rivers. At Blind river landing, the rock (413), first seen and widely distributed in the vicinity, is massive, well glaciated, dark colored, apparently composed of augite in a crystalline groundmass, with many interbedded grains of reddish feldspar (oligoclase) and fewer grains of a pale greenish feldspar. It is therefore a diabase like that at Thessalon, but with the individuals larger. No quartz can be discovered.

On the east side of the bay, near the upper sawmill at Blind river, is a red, vitreous quartzyte (414), very obscurely bedded. Close by, on the south, is a diabasic formation. Next follows another mass of quartzyte, more distinctly bedded, having a dip of 48° in a direction S 12° E. The intervening diabase is also bedded.

In the cut of the Canada Pacific Railroad are irregular alternations of vitreous quartzyte and diabasic rock, but the two are not seen to be interbedded. Their relation is one of unintelligible confusion. The diabase is often quite slaty, but is in isolated and fragmentary masses, lying in all positions in reference to the structure. There seems to have been a junction here between the quartzyte and the diabase, but both are broken into fragments, and the two are mixed in great confusion. The quartzyte, however, can generally be seen to have a tendency to a southeasterly dip, and to strike northeast. The diabase sometimes shows bedding coincident, but the bedded character is not persistent, and we cannot find the diabase anywhere passing under the quartzyte. In some places it terminates by a vertical joint against the quartzyte. The quartzyte, in approaching the diabase, sometimes becomes darker, without ceasing to be strictly a quartzyte. Some of the slaty patches of the so-called diabase become distinctly siliceous, without the presence of isolated grains; and the rock thus acquires the character of a siliceous argillyte (418) in its exterior aspect. I did not discover the evidence that these siliceous slates constitute any part of the quartzyte formation rather than of the so-called diabase slate. They are intermediate between the two.

North of the cut of the railroad at Blind river is a wide area occupied by rocks of the same general character, that is, quartzytes and diabases, but chiefly here, diabases. Of these, one variety contains only a pale greenish feldspar (415); another contains also a pink feldspar (416). The greenish feldspar, in both varieties, tends to become confluent with the dark mineral, and form a feldspathic ground mass In other specimens, the dark mineral remains well isolated, and in places tends to a lamellar crystallization (417).

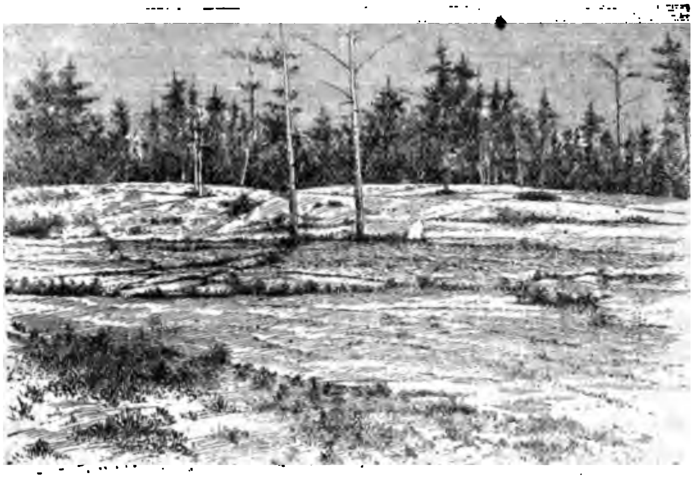


Fig. 12.—*A field of diabase, Blind river, Ontario.*

Similar alternations of quartzyte and diabase are found in all the surrounding regions, and upon the islands contiguous to the mouth of the river.

On the railroad track, one mile west of Blind river, we find diabase apparently identical with that at the sawmill.

About one and a quarter miles west of Blind river, south side of the railroad, is a large outcrop, mostly diabase; but there is a mass of bedded quartzyte in it, twenty-five feet wide, and striking N. 70° E. It is a white, compactly granular rock, distinctly bedded, with a dip of 75° toward the higher mass of diabase. The latter appears both sides of the quartzyte, but it is not revealed whether the quartzyte is interbedded. The upper junction with the diabase is nearly vertical as far as indicated, but dips southward about 85° apparently, so that the beds of quartzyte are intersected by the diabase. On the north junction, the contact is also about vertical, but dips rather northward than southward. The quartzyte traced eastward a few rods, is seen to terminate, the diabase connecting from the south to the north side. On the west, the quartzyte passes under low ground and disappears.

This case is very similar to one in the Thessalon valley illustrated in fig. 8. The general relations of the quartzyte and diabase may also be compared with those seen at localities about the mouth of McBeth's creek and in the Thessalon valley.

At about two miles from Blind river, on the west side of the west mouth of the river, occurs a quartzyte dipping about N. N. W. This is soon succeeded by diabase of the familar sort.

At two and a half miles from Blind river, is an outcropping of much quartzyte, having generally a dip toward the northwest, with reddish color, varying to dark gray, and a vitreo-granular texture. Some patches are of a greenish color, but still completely siliceous.

At the Missisagui river, is a rock-cut on the railroad, one and a half miles from the mouth of the river. Here is a distinctly bedded structure dipping west about 45°. Of course, this may all belong to an erupted rock It may also be the remains of an originally sedimentary arrangement.

Some of the rock (419) is bluish black, with an augitic groundmass, in which are imbedded individuals of red feldspar. These are sometimes pretty sharply outlined grains, a sixteenth of an inch in diameter or less (421). Sometimes the red feldspar is in minute blended grains and strings, as if just emerging into existence (420). Mixed with this rock, are angular masses of red quartzyte (424), tending to a disposition structurally similar to the last, but certainly without evidence of true interbedding. Portions have a petrosiliceous look (425).

In some of the joints between the two kinds of rock, are sheets of dark slaty chloritic rock (422) which, of course, may have resulted from friction, and probably have, though also, possibly remnants of an originally sedimentary structure.

Most of the rock is a bluish black mass, apparently consisting of augite and feldspar—thin edges being translucent.

At the mouth of the Missisagui river, on the west side, is a large boss of diabase (426). The great mass appears to be augitic; but feldspar is present in white branching nuclei. In contact is a bed of vitreous quartzyte—real gray or smoky flint (427).

On the east side, at the extremity of the promontory, is a great mass of flinty quartzyte, striking N. 74° E, with a dip south of 74°. The stratification is but little undulate, but diagonal bedding is frequent. Bands of the rock present the character of siliceous slate. This flint is at least 180 feet thick. It is succeeded on the north by compact diabase. The junction between the two seems to be vertical; but its bearing is N. 66° E. and therefore intersects the bedding of the quartzyte. Still beyond, the quartzyte reappears.

In proceeding eastward from the point at the mouth of the river, it is seen that the quartzyte of the point, after reaching a total thickness of 225 feet, is succeeded by dark diabase.

At the mouth of Little Bear creek, one mile east of Missisagui, diabasic knobs appear, which continue along the coast eastward. Occasionally, a section of bedded quartzyte appears alongside. In one instance, the junction could be traced 60 feet under water. Then, on the east side, the quartzyte terminated in a perpendicular section, descending into Black river.

This coast, between Missisagui and Blind rivers, is mostly quarzyte of a vitreous variety and steep dip. About one-fifth is diabase. Vast quartzose masses, with the angles due to bedding and jointing, can be seen passing, in many places, into twenty or thirty feet of water.

In a comparision of the geology of the Missisagui and Blind rivers with that of the Thessalon near the mouth, we find this difference observable. The quartzyte is more vitreous, and has a higher dip than that north of Thessalon, and is entirely destitute of pebbles and fragments. The diabase is mostly finer textured than that about Thessalon and Bruce; but on the contrary, portions of it are coarser textured, and take on the aspect of hyposyenite, or syenite of the Germans. That supposes, however, that the pink feldspar so generally present is orthoclase; but the augitic appearance of the dark mineral would render that supposition improbable. The mode of crystallization moreover, is little like that of syenitic rocks.

4. *Generalization from observations made on the Huronian of Ontario.* —The observations thus reported are deemed sufficient to convey a just conception of the meaning of the Canadian geologists in proposing the Huronian system. It only remains to correlate them, and ascertain what state of facts gives rise to the phenomena observed.

It is very evident that a large volume of eruptive rocks, mostly diabases and norytes, is present with a great thickness of rocks of undoubted sedimentary origin; while an equal volume of obscurely slaty character, without quartz, presents an ambiguous aspect. The latter appear to constitute the "green chlorite schist" of Logan. At Bruce and Thessalon, they occupy the general surface; and, as far as external appearances go, might be either an ancient and much altered overflow of erupted matter, or a highly altered deposit of sedimentary origin. In several instances noted, the quartzytes contain large angular fragments of such character that they seem derived from the "green chlorite schist," or diabase schist, as I have sometimes styled it; and this circumstance would give countenance to the theory that the latter are older, and probably sedimentary in origin. The uniformity, in the trend of the obscure slatiness observed, points also to a sedimentary origin. On the other hand, the microscope reveals in the minute structure, a multitude of small, highly refractive crystals, imbedded in a large volume of amorphous matter. From some localities, rock-sections contain many amygdular forms, refractive, and not pleochroic in white light, but bluish-green crystalline in polarized light, without change on rotation. While I do not consider a sub-crystalline structure demonstrative of a non-sedimentary origin, but only of a non-sedimentary present character, I am led to assume, for the present, that the slaty sheets covering the surface about Bruce and Thessalon, and generally about the Blind and Missisagui rivers, in the regions examined, are really ancient overflows of erupted material. Strongly corroborative of the correctness of this assumption, are the minute amygdular structures just mentioned, and the macroscopic amygdular forms described near the head of the bay at Thessalon; since, on the accepted explanation of the origin of such features, the vicissitudes of a metamorphic sediment supply conditions less suited to their production than do the conditions of an erupted or intrusive mass.

Whatever may be the origin of the so-called diabasic slates of the coast, undoubted diabases, norytes and gabbros exist in frequent occurrence and great abundance in the interior; and especially along the valley of the Thessalon. But these masses do not occur in the condition of wide overflows I found them nowhere occupying extensive surface areas, or interbedded between sheets of clastic formations, nor even underlying them. They generally appear as dikes with nearly vertical walls, holding various positions in reference to the lines of sedimentation of the rocks which they pierce. Only in one instance did I observe a diabasic mass resting on the sedimentary rocks. But I could not affirm that they nowhere in the interior exist as interbedded formations.

Passing by all these intrusive and quasi-eruptive formations, the characteristic features of the Huronian are to be sought in its clastic rocks. Of these, we find conspicuously, two great quartzyte formations—the Ottertail and Thessalon quartzytes—pretty closely approximated in vertical relations, and two great argillitic slate formations, also closely approximated in a vertical sense—the upper and lower Plummer argillytes. Whatever uncertainty may exist in reference to the straligraphical positions of subordinate beds, there is no doubt that the relative situations of these is correctly shown below:

Ottertail (white) Quartzyte.
Thessalon (red and gray) Quartzyte.
Plummer (conglomeritic) Argillyte. $\begin{cases}\text{Upper.}\\ \text{Lower.}\end{cases}$

These constitute the principal part of the mass of Huronian strata. The Ottertail or white quartzyte attains a vertical thickness which I would estimate at four thousand feet. This estimate is based on the distance traversed across the formation in proceeding north a mile and a half from Ottertail. The Thessalon or red quartzyte is estimated to have a vertical thickness of five thousand feet. The method of forming this estimate has been explained in the preceding pages. The Plummer or conglomeritic argillyte has also a great thickness. In the region north of Ottertail and Rock lakes where the northern outcrop occurs, we travelled across the trend of the formation for a distance of over two miles, and the northern limit, apparently, was not reached. At Murray's Corner the dip is 75°, and at the southern margin, it is 48°. If we assume the average dip at 50°, and the horizontal distance across the formation, at two miles, we calculate the vertical thickness of the Plummer argillyte (upper and lower), as a little over 8,000 feet. There would be little risk in setting down the aggregate thickness of these three terranes as 17.000 feet.

The Ottertail quartzyte is mostly white, subvitreous and massively bedded. It contains few pebbles. The Thessalon quartzyte is less massive, and generally contains ferruginous and argillaceous impurities. The upper portion especially—but all parts to some extent—embraces dispersed pebbles of a siliceous character, often ranged in courses, and among them pebbles of red and black jasper. As boulders of a red jaspery conglomerate are seen on the south, there is reason to suppose the upper portion of the Thessalon quartzyte locally assumes this character; and would thus answer to Logan's "red jasper conglomerate," which he places between the "red" and "white" quartzytes. In my estimate of thickness, I include the conglomeritic portion Some of the pebbles of the red quartzyte are glassy vitreous. It also contains great angular masses of itself.

That which I have designated the Plummer argillyte seems to be divided into two portions, as I shall point out; but both contain, generally, disseminated pebbles. These are mostly reddish, and of the character of granulyte, or granulitic gneiss, up to two feet in diameter. Others are of red jasper, white quartz, graywacke greenstone, syenite and mica-bearing granite. It may therefore, be designated as conglomeritic. It would be misleading, however, to style it a conglomerate, even a "slate conglomerate." Conglomeritic slate, however, is admissible. The greater part of the mass is a slate.

This slate is quite uniformly dark argillyte. Generally, also, it is permeated by a siliceous constituent. In many places it assumes the condition of a siliceous argillyte, and not unfrequently, of a siliceous schist, more or less darkened, but occasionally vitreous. It conveys, however, an erroneous conception to describe the formation, or any portion of it, as a "quartzyte," or even a quartz schist. Some portions may be denominated siliceous schist or flint schist. Aside from the disseminated pebbles the formation is the exact prototype of the dark schists of Gunflint lake of Minnesota, and of the Animike formation of Thunder bay.

These great formations present two series of outcrops. The one is on the southwest of the Thessalon river, with dips in a northerly and northwesterly direction; the other series is on the northeast of the river, with dips southwesterly. Owing to great dislocations, these two series do not precisely face each other. Thus the Thessalon valley marks the location of a synclinal, as announced by the geologists of Canada.

Besides these great type masses of the Huronian, we find some relatively unimportant terranes, whose stratigraphical positions provoke discussion. On the north of Bruce, at the distance of a mile, is an impure limestone, which I will call the Bruce limestone, somewhat earthy, crystalline and thin-bedded. but not attaining, as far as I observed, a thickness exceeding one hundred feet. In the bed of the stream at Ansonia, is an obscure, siliceous limestone appearing to stand vertically: and near Ottertail, is a very similar cherty limestone, dipping conformably with the neighboring quartzyte This I will designate the Ottertail limestone. There can be no risk in identifying these two outcrops, since the rock is very similar in the two, and is peculiar. But on these grounds, the Bruce limestone must be distinguished. Its stratigraphical position also, seems removed.

In addition to the limestones, we find three separated outcrops of reddish felsyte—passing into quartzyte and granulyte. Petrographically, they must be identified but the mode of showing how this is structurally possible affords ground for debate.

Thirdly, we find, especially about the mouth of the Missisagui, a peculiar vitreous, often reddish, quartzyte—along the line of the Canada Pacific railroad surprisingly broken and intermingled with diabasic masses. Its aspect is notably different from that of the Thessalon and Ottertail quartzytes; it contains no pebbles; it is not granular; and it has also, a steeper dip. In constitution it is quite purely siliceous, and about the mouth of the Missisagui assumes the character of genuine flint. I do not feel inclined to regard it as resting in continuity with either of the other quartzytes—still less, as the deep sea representative of the Plummer slate. Petrogrphically, the latter conclusion is reasonable. Structurally, the dip being in the opposite direction from that of the Plummer slate, an anticlinal must separate the two. Still, this is not a fatal objection to the viêw. A real petrographic objection, however seems to lie against it in the necessity of supposing the Plummer slate has undergone so great a change within the distance of 25 miles toward the southeast, while in the opposite direction, it has retained persistent characters as far as Thunder bay and Gunflint lake—a distance in a straight line, at least seven times as great. I shall therefore set the Missisagui quartzyte down as a distinct formation; and this is what I think Logan has intended to do. Travelling over it four miles, from the Missisagui to Blind river, we pass partly in the direction of the strike. That is, the strike is N. 74° E. and the line of coast is S. 80° E. The four miles of coast, therefore, go at right angles, one and a half miles across the formation; and, as the dip at the Missisagui river is 74°, the resulting vertical thickness of the formation, supposing half the distance diabase, is over 3,750 feet. This all depends, however, on the continuance if a dip of 74° all the way between the Missisagui and Blind rivers. No formation of such volume exists between the top of the white quartzyte and the bottom of the Plummer argillyte; and I shall therefore, put it down below the Plummer argillyte.

It remains to ascertain the positions of the limestones and the felsyte. If the Bruce limestone is distinct, as I believe, from the Ottertail limestone, there seems to be no possible position for it but below the Plummer argillyte; and, as the Missisagui quartzyte, assuredly, is not above this limestone, it must lie above that quartzyte.

The Ottertail limestone and the felsyte remain. At Ottertail, the limestone lies constructively above the white quartzyte; but the red (or lower) quartzyte contains pebbles of this limestone; and the latter must hold position, therefore, below both quartzytes. Moreover, at Ansonia, its topographic and constructive position is below the red quartzyte. Its regular stratigraphical place, therefore, at Ottertail, is 9,000 feet below the top of the white quartzyte; but we find it only 250 feet below topographically; and if the neighboring quartzyte were produced to the outcrop of the Ottertail limestone, the latter would appear even above the top of the former. This limestone must, therefore, be raised at least 9,000 feet above its original position; and a fault of this magnitude must run along the valley of the river in this vicinity. This would assign the Ottertail buff and cherty limetone to a position between the red quartzyte and the Plummer argillyte. Sir Wiliam Logan has posited "yellow chert and limestone" between a "white quartzyte chert and limestone" above, and a "white quartzyte" below—apparently within the mass which I have denominated white or Ottertail quartzyte.

Now as to the felsyte, I find it exposed in three localities visited; and in each place I find a small amount of Plummer argillyte at a higher level. North of Ottertail, the super-jacent argillyte has a vertical thickness of about a hundred and fifty or two hundred feet. South of Ottertail, it is not over sixty feet to the summit of the hill which it caps. But both felsyte and argillyte are stratigraphically out of place in the outcrop south of Ottertail. They are far above their normal stratigraphic position. They are also, within three-quarters of a mile of the Ottertail limestone, which I have just now concluded to be raised 9,000 feet by a fault. But in the next place, the felsyte at Ottertail, is topographically 75 feet above the limestone, while, as I reason, its normal place is at least 150 feet below it. The felsyte then, has been raised 225 feet more than the limestone. Another fault of this amount, must therefore, intervene in the 240 rods of surface between the limestone and the felsyte.

Recapitulating and tabulating these conclusions, we should have the Huronian of Canada, as far as observed, constituted, in descending order, as follows:

8. Ottertail (white) Quartzyte.......................... 4,000 feet
  "l. White Quartzyte, chert and Limestone" and "i White Quartzyte" of Logan.
7. Thessalon (red and gray) Quartzyte.................. 5,000 "
  "h. Red Jasper Conglomerate" and "g. Red Quartzyte of Logan.
    (I think Logan's "c. White Quartzyte" must belong here also.)
6. Ottertail Cherty Limestone say...................... 100 "
  "k. Yellow Chert and Limestone" of Logan.
5. Upper Plummer (conglomeritic and siliceous) Argillyte 500 "
  "f. Upper Slate Conglomerate" of Logan, in part.

4. Red Felsyte, granulyte and quatzyte.................. 100 feet
Not mentioned by Logan. The "e. Limestone" of
Logan is lower, and not noticed by me.
3. Lower (conglomeritic and siliceous) Argillyte....... 7,400 "
"d. Lower Slate Conglomerate" of Logan.
2. Bruce Limestone.................................... 100 "
This seems to be placed elsewhere by Logan.
(Logan's "Green Chloritic Slate" is in this interval.)
1. Missisagui (vitreous) Quartzyte..................... 3,750 "
"a. Gray Quartzyte" of Logan.

It will be observed that neither the lower nor the upper limit of the Huronian is embraced in the observations above reported. It may be added, therefore, that the white quartzyte is seen occupying the north shore of the Channel as far as the St. Mary's river, and it appears, also, along part of the north shore of St. Joseph's island. Here I found it immediately overlaid by a siliceous and fossiliferous limestone—apparently the Chazy. The same was observed years ago, at Campement d'Ours and at Sulphur island, six miles south-southwest of Thessalon point The same superposition is reported at all the islands ranged along parallel with the north shore of the Channel. It thus appears that the Huronian is a system following downward immediately below the Lower Silurian, in this part of the continent. If no intervening terranes are wanting, it follows that it occupies the position of the Taconic of Emmons and the Lower Cambrian of Sedgwick.

At its lower limit, it must be succeeded by formations of vitreous quartz, red jasper and graywacke, besides greenstones, red granulytes, red gneiss and mica-bearing granite; since fragments of all these occur in the Plummer argillyte. It may be admitted that the quartzyte pebbles of the argillyte were derived from the Missisagui quartzyte; but the red jasper and graywacke must have been derived from a terrane older than the Huronian, and evidently newer than the crystalline masses of the Laurentian. The character of this underlying system will appear in the records of my subsequent observation.*

I should not do justice to my sentiments nor to the labors of the

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* A condensed synopsis of the foregoing observations and inferences was presented at the New York Meeting of the American Association for the Advancement of Science, under the title of "The Huronian System of Canada." Nothing, however, has appeared in print from my pen. Other communications were similarly presented by professor N. H. Winchell, under the folowing titles "The Slate Conglomerate of the original Huronian the Parallel of the Ogishke Conglomerate of Minnesota," and "The Animike Black Slate and Quartzyte and the Ogishke Conglomerate of Minnesota the equivalent of the original Huronian."

Canadian pioneers in the Huronian field, if I should fail to acknowledge explicitly the general accuracy of their reports, as far as my own observations have gone. When we consider the great intricacy of the geology, and the extreme difficulty of travel through the region when settlement was in its infancy, the great amount accomplished with such accuracy of detail, may well command our admiration.

I wish to record an observation supplementarily, respecting the surface geology of the district about Thessalon. The region generally is covered by an alluvial deposit. This has given the usual argillaceous soil and subsoil, accompanied by much standing water. But at the same time, this soil when well cleared and drained, makes very fine farms, and is already much improved. Crops of timothy grass and clover are especially rank. I saw also, good spring wheat, oats and peas. Still, so far as I observed, proper drainage is generally neglected.

Over the alluvial clay, I observed extensive regions occupied by fine sand, and here is a truly warm and productive soil. I saw Indian corn growing in some gardens; and it was nearly as rank as that in southern Michigan. But I saw none in the fields; and I presume the autumnal frosts are too early for field corn.

I observed numerous ancient beaches at elevations within 100 feet of the present lake level. Indeed I should suppose an ancient beach would surround each of the rocky knobs which must have projected as islands from the former lake—as many still project above the actual surface of the North Channel. I crossed one old beach which had low land on both sides, and must have been a point, perhaps submerged, at the time of the former extension of the lake—just as Thessalon point at present, projects miles into the modern lake. That Thessalon point is an ancient beach or reef I have ascertained—but still, there may be a foundation of erupted rock.

§ 3.—OBSERVATIONS IN OTHER REGIONS OUTSIDE OF MINNESOTA.

1.—*The Marquette Iron Region.* The geological position of the iron ores of this region has been generally, though not universally, regarded as within the Huronian system. The observation of the true character of the typical Huronian rocks of Canada rendered it necessary to ascertain how far the iron-bearing rocks of Marquette agree with them, and, in case of difference, to determine whether any portion so agrees, and in what respect the other portions disagree. It was also necessary to determine whether the iron-bearing rocks of the Marquette range can be identified with those of the Vermilion range, a lithological assemblage which was supposed to stretch to the northeastern limit of Minnesota.

My studies in this region were directed only to certain points, and with reference to information desired on particular questions. The research began at Ishpeming, and a few memoranda of facts are here recorded.

I am much indebted to Mr. Hall, the superintendent of the Lake Superior mining properties, for the use of means of conveyance, and for his company and many details of information. In the office I was shown a very extensive series of drawings of the mining property, including numerous vertical sections across the iron-bearing lodes, and along their axis. Mr. Sturtevant, the engineer, had the goodness to prepare for me two sections across the soft hæmatite deposit, and one along its axis. These are presented below on a reduced scale.

The accompanying diagrams show that the great iron-bearing lodes of the Marquette region do not occur in isolated lenticular forms, as has been sometimes supposed; but are really interstratified in the formation, as at Tower. Here however, all the stratification is much disturbed and wrinkled. Besides what these diagrams illustrate, Mr. Hall pointed out on the ground, the evidences that the deposit in transverse section was originally bent into the form of an S, giving thus at differents points in its breadth synclinal and anticlinal attitudes.

Mr. Hall showed me, also, many samples of the gold taken from the Ropes gold mine, and other samples of gold-bearing quartz from a new find recently made on the property of the Lake Superior Company. These localities are both within three or four miles of Ishpeming, on the north.

In an old opening of the Lake Superior Company, Sec. 19, T 47-27 (rocks 453, 454), the deposit of iron is seen to run east and west, with a dip N. 63°. The hanging wall is a quartzose conglomerate. This, however, sometimes continues through the iron deposit in modified character.

Twenty rods north of this place, immediately east of the Saginaw mine, is a boss of a curious conglomerate (455), consisting largely of iron—a sort of imperfectly bedded groundmass of a hæmatitic character—in which are imbedded rounded and partly angular pebbles and fragments of red jasper, white quartz, flint, glassy quartz, and less important fragments. This has been bored into, and, according to Mr. Hall's recollection, it is at least 400 feet thick. Here the Lake Superior Company did a good amount of mining; and the Saginaw

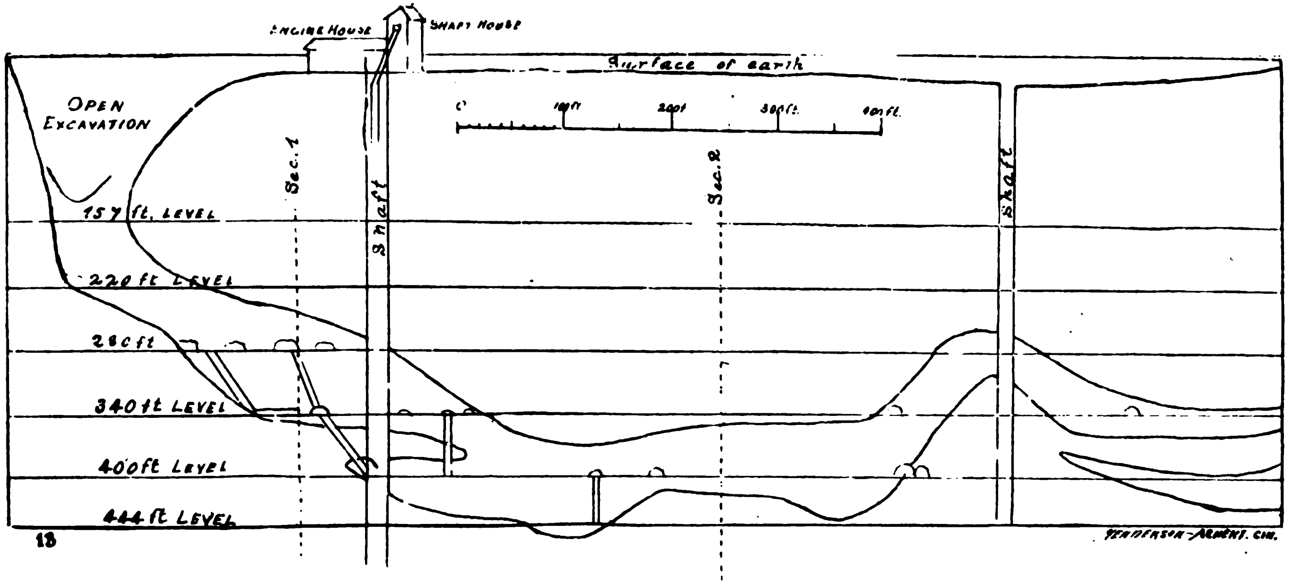

Fig. 13. *Vertical east and west section along the axis of the soft hæmatite deposit of the Lake Superior Iron Company.*

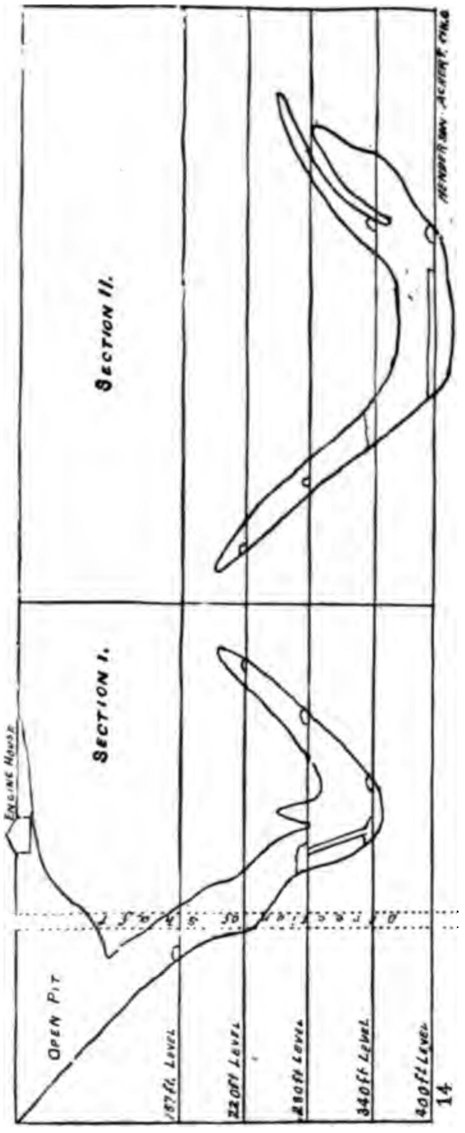

Fig. 14. *Vertical north-south sections across the same deposit, at points marked in fig. 13.*

ompany did much on the westward continuation of the deposit. ut all work is now abandoned.

About one and a half miles west of Ishpeming is an outcrop of a ark, argillitic, sericitic slate (456). It dips N. 10° E. at an angle f 70°. Conformable with this is a bed of gray, rusty-speckled, ranular quartzyte (457) underlying the other.

From information gathered at Ishpeming from Mr. Taft, the chemist of the Cleveland Iron Mining Company, from Mr. J. R. Wood, and others, it appears that a synclinal exists in this vicinity, with a southern outcrop, on which the town is located, and another three or four miles to the north. The downward succession of the beds in this synclinal is as follows: 1. Red slate; 2. Black slate and mixed ore; 3. Ore; 5. Talcose rock, so-called; 6. Dioryte The red slates are banded hæmatite and jasper—pretty hard. The black slates are magnetic jasper, and the mixed ore is similar to the red slate bed, but contains more ore. The talc is essentially argillitic. This is also true of the "chlorite rock," so-called—a rock also styled by some, "talc," and by the miners, "soap rock."

One and a half miles north of Ishpeming, on the Deer lake road, is an outcrop of quartzyte, having a dip quite steep—about 70°. It contains beds of quartz pebbles.

About two and a half miles from Ishpeming, on the road to Deer lake, and one-third of a mile south of the saw-mill at Deer lake, is a high knob on the right of the road. It consists of nearly vertical slates (458), which would formerly have been called talcose. In some portions, however, are developed multitudes of feldspar crystals. It is, therefore, in the condition which I have styled "porphyrel" (459).

Climbing to the top of the hill, we find an obscure conglomeritic structure, like that at Stuntz's island, in Vermilion lake. The resemblance is confirmed by the presence of isolated portions looking serpentinous or talcose, and by the existence of many obscure, intersecting quartzose veins. The obscurely outlined pebbles, it should be recorded, are essentially identical with the country rock, as at Stuntz's island.

All this confirms the parallelism of the Marquette and Vermilion iron-bearing groups, and the non-Huronian character of both.

In the highway by the bridge at Deer lake, and about in the strike of the ridge last mentioned, is an outcrop of rock (460, 461), which to me appears sedimentary; but assuredly it is much altered, and presents a quasi-eruptive aspect. It is admittedly the equivalent of the Stuntz island rock; and they who regard that as eruptive will pronounce this eruptive also. The rock here contains foreign pebbles; and I regard that as conclusive evidence of a fragmental origin. The schistosity, also, is completely conformable with that of the neighboring sericitic slate.

On the west side of the bridge at Deer lake the rock (462) is highly and distinctly conglomeritic; but having a slaty structure, with beds standing vertical. It might by some be regarded as having a basaltic structure. In places it passes to a still more eruptive-looking rock. The resemblance to Stuntz island is maintained. Still, I think the formation was sedimentary originally, and that it retains distinct traces of its original condition.

The conglomeritic aspect comes out chiefly on the weathered surfaces. Some of the fragments are angular, some rounded, and many elongated in the direction of the structure, i. e. vertically.

Twenty rods south of the last point, along the railroad west side of Deer lake, occurs a quartzyte (463) dark gray and red in bands. This dips S. 25° E. at an angle of 55°. The rock is rather vitreous. The lower part of it is darkened by the presence of hæmatitic material apparently, and contains thin bands of hæmatite. The higher part becomes almost uniform in color, of pinkish gray. Still higher it is whitish. The quartzyte and the slate are not seen in juxtaposition. An interval of four rods separates their nearest outcrops. The vertical structure of the slate, however, is strikingly unconformable with the dip of the quartzyte; and favors, perhaps the theory of the eruptive origin of the slate.

At a point about two and a half miles east of the Ropes gold mine, (1069), near the charcoal pits, we observed a large pile of rock-fragments said to have been brought from the gold mine to use as a flux. The fragments indeed contain a large percentage of calcium carbonate; but there is present also so large a quantity of talc that the material is said to have proved unservicable. Yet we obtained fine specimens of amorphous (464) and crystalline (465) talc. Noticing that the rock on weathering acquires a deep stain of iron rust, we judged that it probably has the composition of ankerite.

At the Ropes Gold mine, it was observed that the gold-bearing quartz vein occurs in a rock appearing like a chlorite slate (466)—though probably a compact argillyte—appearing to be the same formation as that seen at the knob east of Deer lake, and on both sides of the bridge at the lake. The shaft at this mine was stated to be about 360 feet deep with seven levels. In the mill twenty stamps are in operation.

On the return to Ishpeming, we examined a spot on the opposite side of the road from the knob before mentioned, 458. Here is a formation consisting of thin-bedded quartz with laminated, sericitic schist (468) more or less siliceous, intervening. Dip S. 15° E. amounting to 64°. The formation occupies the interval noticed on the opposite side of the lake, between the nearest outcrops of the quartzyte and slate. The gap is evidently due to the easier disintegration of the thin-laminated rock.

In company with Mr. Taft, chemist, we visited the Cleveland mine, and made a careful examination of the "dump." At our request Mr. Taft took a sample of the green argillyte, Rock 469a, and a sample of the ashen argillyte, 470a, to subject to careful analysis. The result, as subsequently communicated to me, and which will probably be elsewhere published in full, establishes what was before stated, that the rock variously known as talcose slate, chlorite slate, or soap rock is essentially an argillyte.*

At this mine were found martite crystals (471); and Mr. Taft showed a specimen of an iron breccia, very similar to the conglomerate seen at the Saginaw mine, 455. This, he says, is terminated abruptly by the overlying quartzyte.

At the Michigamme mine, we found the rock immediately over the ore to be a quartzose chlorite schist (472). Above this is a thin-bedded quartzyte, similar to that seen under the quartzyte east side of Deer lake.

The first knob north of Michigamme mine is formed of dioryte, so-called (473). The higher knob, farther north is formed of "granite" (474). Immediately in contact with this is a greenish quartzyte, which passes by transition into the granite. Professor Irving, who accompanied us, represented this as the usual character of the contact. It might also signify that the "granite" was originally a sedimentary rock, but containing more feldspar-making elements than the quartzyte, metamorphism changed it to a rock of the granite series, but could not make anything but a quartzyte of the overlying beds.

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* The samples bear the numbers of the series of N. H. Winchell. The analyses done by Mr. Taft were omitted accidentally in the proper place, and are appended here.

	No. 1235. (469a)	No. 1236 (470a)
SiO_2	27.13	28.35
FeO	21.50	2.38
Fe_2O_3	9.80	11.30
Al_2O_3	24.28	36 54
CaO	trace	.86
MgO	4.21	13.21
H_2O	7.10	2.89
Total	93.97	95.03

Mr. Taft remarks: "They are both short about five per cent and I fail to account for it, except that they may contain soda and potassa. I have not means for determining these elements properly, and have used all of one of my samples." [N. H. W.]

I proceeded to the summit of this range and worked eastward in search of a gneissic structure in the granite, but the surface was generally concealed. Descending at the distance of about twelve rods, I found the quartzyte (475) again in contact with the granite; but the contact here is abrupt. I found the granite intersected by a diabase dike (476).

A short distance southeast of here is a small, sharp, high cliff of quartzyte, thin-bedded and with interlaminations of sericitic sheets (477). These contain multitudes of garnet-like minerals. A short distance south of this is a ledge, unquestionably in place, dipping southward 66°. The dip in the sharp knob is 63° toward N. 28° W.

At the east end of the marsh is a precipitous exposure of dark gray, distinctly bedded quartzyte (478), with a diabase dike through it. The dip is various in direction and amount. The great mass, however, is nearly horizontal, or slightly eastward-dipping.

In visiting the Swan mine, east of Negaunee, I observed on the dump heap interlaminated fine sandstone and hæmatite (479), and, in contiguity, chalcedonic silica and hæmatite (480); and finally, jasperoid laminæ (481) and hæmatitic. All these were necessarily formed in continuity by the same kind of action in the same spot. But it is incredible that all these should be the product of eruptive action.

At the lower shaft of the Buffalo mine I saw the same material taken out as at the Swan mine. As these materials are above the ore, it would follow that ore probably underlies them at the Swan mine. The ore is soft and earthy. The open excavation near the upper shaft shows the ore and country rock in great confusion; but, in general, with a northerly and steep dip.

One-fourth mile north of the Buffalo mine, on the railroad, is an outcrop of quartzose schist and slate. The so-called quartzyte (482) is not quartzyte. It is greenish chloritic and quartzose.

Across the railroad is a black argillyte (484), thin-laminated, dipping northerly, but at a much lower angle than the "quartzyte," so-called. *It is unconformable with the quartzyte.* The slate (483), interbedded with the "quartzyte," is decidedly another formation unlike the argillyte of black color.

It is worthy of particular remark that this black slate *resembles the Animike black slate;* and its unconformability with an underlying formation is also very suggestive. The dip of the black slate is 40° toward N. 51° W. The greenish slate, or the so-called "quartzyte," on the opposite side of the railway, dips 47° toward S. 62° W; at another place, S. 82° W.

Near by I find a contact between the slate and the sandstone (quartzyte) like the following:

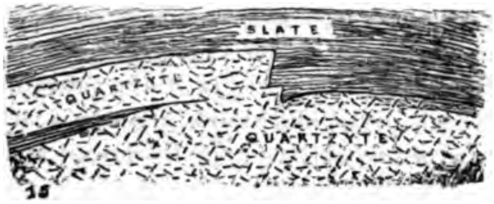


Fig. 15. *Contact of slate and quartzose sandstone, one-fourth mile north of Buffalo mine, near Negaunee.*

This slate is further mixed with the sandstone by imbedding of flakes.

The unconformability of the two slates is further illustrated and established by observations on the neighboring hill-slope a little further northwest. The argillitic slate (485) is here largely developed. It possesses a vertical slaty structure; but it has an unmistakable sedimentary dip everywhere toward N. 51° W., conformably with that of 484. This, therefore, is a higher stratigraphical position than that of 484; but it is unmistakably the same formation. Is it Animike?

The opening of the Iron Cliffs Company is adjacent to the "Sam. Mitchell mine." The work here is arrested by an anomalous disposition of formations. The ore deposit is cut off by a quartzyte. This quartzyte is south-dipping, and a shaft was carried down along the south side of it, when it was intercepted by a north-dipping quarzyte (486). The two quarzytes seemed now to fold together and inclose a selvage of green rock. Along this selvage the shaft is continued almost vertically. The quartzytes are both greenish, and do not differ except that a few ferruginous patches occur in the southward dipping one. This is not the place to offer any reasoning as to the probability of recovering the ore deposit. Still, it may be said that the bedding of the formation in general is northward, and the southward-dipping quartzyte should be of the nature of a vein with the ore body under it, more or less displaced. This view is favored by what is seen in the brush one-eighth of a mile north of the mine, to which superintendent Sodergren accompanied me. Here is an outcrop of quartzyte (487), dark gray but granular siliceous, thought by him to be the southward-dipping quartzyte. A few rods farther north, also, are some test-pits and one shaft planked up. From the bottom of the latter was thrown out a quantity of quartzyte fragments of dark gray color, resembling the southward-dipping quartzyte, but, still, not of grains so uniform in size and constitution. In a cliff west of these localities is a large outcrop of quartzyte, so-called, dipping north; but this is a different quartzyte.

It looks on the whole, therefore, as if the prevailing dip of the formation hereabouts were northward, and the southward-dipping quartz a mere vein, of probably no great thickness; and the ore ought to be under it.

Some observations were made in the district north of Negaunee and Teal lake. North of the east end of Teal lake is a massive range of quartzyte (488). It is gray, granular, vitreous, blotched with red, thick-bedded, with various joints, and an appearance of sedimentary structure dipping south at an angle of 65°. This quartzyte, in its physical characters, is unlike that (487) in the ridge visited with Supt. Sodergren. It is much more compact and vitreous; that is granular, with intergranular cement; still, the grains of this are distinctly defined, though glassy. The formation has some thin seams of black crystalline hæmatite.

At the west limit of this quartzyte knob we find a deposit of sericitic schist, argillitic and ferruginous. Its relation to the quartzyte is ambiguous. It looks like a vein or dike, but is exceedingly schistose, and its schistosity is not conformable with the bedding of the quartzyte. The knob next west of this is all of the same quartzyte. The range seems to be a continuation of that north of Ishpeming.

On the northern border of the city of Negaunee, and not far removed from the south side of Teal lake, is a high dioryte knob or ridge. On the north side of this is the Eldridge mine. The ore body is not reached. The surface rock was "soap rock;" and this was continuing at the depth of 153 feet. The dip is southward about 60°. For a hundred feet a good deal of iron had been mixed with the "soap."

At the Hartford Mining Co.'s mine, also on the south of Teal lake, and half a mile north of the Eldridge, a shaft was sunk sixty feet deep. There they struck ore and are now drifting east and west—the ore having a southerly dip. The overlying rock was banded, siliceous hæmatitic schist. The ore is a soft rich hæmatite.

At the Cambria mine south of the west end of Teal lake, we ascertain that the general dip of all the rock in this neighborhood is steeply southward. There is a large main deposit of ore, on which are located the Hartford, Cambria, Lily, and another mine. The Hartford and Lily are still working, but the Cambria has ceased to be productive. The working ended with jasper on all sides. They have drilled into the jasper in various directions. North, they come into banded, siliceous hæmatite, similar to the overlying rocks. On the south they claim to have found ore.

Since the loss of the main deposit the management have sunk a new shaft 350 feet, and have drifted in various directions at the 2d, 3d, 4th and 5th levels, and found thin, irregular beds of ore, one of which trends northwest, but is only one or two feet thick. On the sixth level they found no ore.

The general conclusion geologically is, that the stratification is extremely irregular, and ore deposits not to be long depended on.

A few studies were made at Marquette. At the end of Bluff street, on the peninsula by the saw-mill, is an outcrop of sericitic schist (489) with vertical schistosity, and crumbling to chips. It is drab, pervaded by dashes of a dull pink color. The bedding is wavy, inclosing lenticules of quartz (490). The sedimentary bedding planes are visible, dipping N. 8° E. at an angle of about 15°.

Twenty rods farther northeast, are rounded glaciated bosses (491) of an ambiguous character, but reminding one of rocks at Thessalon; yet nowhere plainly diabasic. Over the surface are seen streams looking like fluid currents, with many oblong and lenticular pieces of the country rock—such as occur at Thessalon, and many localities in the Vermilion region. At the same time, there are places which reveal a structure dipping northward, and looking sedimentary. The rock varies much within short distances, in texture, hardness and composition.

Near the light house, but not at the point, rises a rounded smooth boss (492), as before, but with very distinct banding on the surface, which dips N. 1° E. at an angle of 71°. Careful examination with a lens reveals no free quartz, but the rock is rather hard, and rings under the hammer. Silica is probably present; though scratched on the fresh or weathered surface, there is no indication of a free quartzose constituent. It has scarcely the hardness of feldspar on the fresh surface; and the whole rock, as far as I can make out in the field, is a felsitic schist, though the feldspathic ingredient does not appear to be orthoclase. This is the best conclusion I can reach from the data supplied at this spot.

This formation strikes a few rods to the north of the last two localities. The same sort of rock continues toward the light house; but the exposure there is further north, and stratigraphically above. A dike of diabase is seen cutting it.

At the Light House point, Marquette, the formation presents a banded structure, and a striking appearance of steeply dipping sedimentary rock. Here also, is the felsitic rock weathering red, and in places becoming a porphyry (493). The banded schist weathers dark, and on fracture, is dark. It appears to be an intimate mixture of feldspar and hornblende; containing many glistening points. Thin scales have a dark greenish translucency; and the weathered surface has a fibrous, sericitic aspect (494).

This formation is intersected by dikes nearly parallel with the bedding, and by another great dike making an angle of 60° with the first set. Further research reveals the fact that the felsitic and porphyritic mass is in the nature of a broad dike nearly conformable with the dark-banded schist; but really bounded on both sides by a slightly discernible unconformity. The porphyry and schist are intersected by small diabase dikes parallel with the schistic bedding; and that gives the appearance of bedding to the porphyry. Then, also, the whole formation is cut by two great dikes running nearly north and south.

In one place, I saw a banding transverse to that of the schists; and that awoke the suspicion that the main banding may have been caused in a similar way. But after careful study I concluded that the transverse banding is in the nature of veins Sometimes, in the porphyry, —which in many places is simply felsytic—the transverse veins give the appearance of a woven fabric.

Proceeding toward the extremity of Light House point, I find a similar schist continuing; but opposite the Light House, it is crossed by an enormous dike of greenstone, at least a hundred feet wide, and divided longitudinally by joints about fifteen feet apart; and these being unequally eroded, leave great gaps, as if each section were itself a dike.

Some portions of the schist become exceedingly hard and diabasic, and I find again the cross banding noticed above.

On the north side of the point is another great dike, about thirty feet wide, belonging to still another system; for it trends exactly east and west, and dips north at an angle of 77°. It is granular and glistening, but there is no free quartz. The powder is bluish-white, and the glistening seems to be due to faces of labradorite. I made a search to find the intersection of this dike with the great north-south dike immediately east of the light house. This dike continues beyond the place of intersection, and runs north of the light house; but at the place where the intersection should be, neither dike is certainly identifiable. I judge, however, that the east-west dike cuts the other. If so, the east-west dike is next to the last geological phenomenon in the history recorded in the structure of the rocks forming this point. The granulitic veins which I have found intersecting all the other dike structures, undoubtedly intersect this also. We should have therefore, the successive epochs of the geological history of the point marked off as indicated in the following diagram:

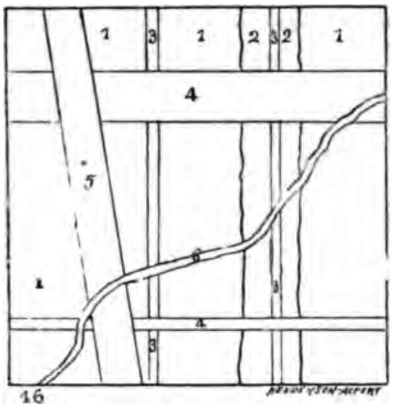


Fig. 16. *Diagram illustrating geological epochs evidenced at Light House point, Marquette, Michigan.*

1. Epoch of the fundamental dark schist.
2. Epoch of the porphyry.
3. Epoch of the little dikes, nearly conformable with the schist, but not entirely so.
4. Epoch of the great north-south dikes.
5. Epoch of the great east-west dikes.
6. Epoch of the granulitic veins, which cut the great dikes.

This is a new and instructive example to illustrate well known principles in structural geology.

The few statements made in reference to the mode of occurrence and the associations of ore deposits in the Marquette district, will, it is hoped, possess some interest for citizens of Minnesota connected with the iron developments of the "Vermilion Range." The facts noted of a purely geological character reflect important light on the geological parallelism of the Marquette and Vermilion ranges; and indirectly, on the economic questions concerned in Minnesota mining. It is only the geologic outcome of the comparison, however, with which, in this place, we are concerned; and it may be stated as I understand it, in the following propositions:

(1.) *The Marquette iron-bearing rocks are of the same age as those of the Vermilion Range.* Their geological position is immediately above the crystaline schists and gneisses; and there are indications, as will be shown, of a position, as in Minnesota, beneath other slates, in unconformable relations. The fundamental sediments generally, are but little crystalline, but are highly altered, often almost to the point of fusion, and sometimes, to the point of true crystallization. They consist largely of argillytes, ranging in nature, from proper to chloritic, sericitic, hydromicaceous, siliceous and hæmatitic; and, in condition, from earthy to graywackenitic, felsitic, porphyritic and diabasic. The ore bodies are true bedded constituents of the system, subject to all the usual accidents of stratification; the most important of which are liability to expand and contract and even to pinch out, in the direction of the axis of the lithologic folds. The occurence of an obscure conglomeritic structure in both regions, is a point of resemblanee which is almost demonstrative. The inclusion of masses of serpentinous or parophitic character, has the same significance. A great abundance of red jaspilyte and jaspilitic iron schists is a common feature of the Marquette and Vermilion districts. In both, the jasper and jaspilitic ore are disposed in layers conformable with the bedding of the hæmatite and of the inclosing schists; and in both, similar indications exist of a sedimentary and aqueous history The observations made at the Swan and Buffalo mines may be here again referred to. Of clastic rocks, the quartzytes of the Marquette region are little known in the Vermilion region. Rocks of eruptive origin are common in both, but in the Marquette region occur both as dikes and intruded beds—though a question remains as to the real origin of the dioryte beds. While the Vermilion rocks have been subjected to one grand system of disturbance, which has left them almost universally in a vertical attitude, the Marquette rocks have been thrown into several folds, within each of which the constituent strata may be found in all attitudes.

(2.) *The Marquette iron-bearing rocks are not of Huronian age.* While the opinion is not new that they antedate the Huronian, it has been generally admitted that they fall within that system. That they are older than Huronian is shown by a four-fold line of evidence. (*a*). *The rocks are different.* In the original Huronian, the argillytes are almost exclusively black and carbonaceous or magnetitic, instead of bluish or ashen and hæmatitic. They are more prevalently siliceous or flinty. The quartzytes attain a more enormous development, are much purer, especially the upper, and hold position entirely above the argillitic member. (*b.*) *The Canadian Huronian succeeds immediately beneath the Palæozoic System* The Marquette strata do not. The Marquette strata are succeeded immediately downward by crystalline schists. The Huronian strata are not. (*c.*) *Some evidences exist of an unconformable, overlying, sub-palæozoic system in the Marquette region.* I refer here, both to the unconformability described in the foregoing notes in the vicinity of the Buffalo mine, and to major Brooks' brief notices of highly carbonaceous black slates occupying a position higher than the Marquette argillytes. (*d.*) *Proof is to be adduced in this report, of the unconformable subterposition of the Vermilion iron schists relatively to the Animike slates.* If the Marquette and Vermilion rocks are mutual equivalents, the former must hold position beneath the same system—that is, beneath the Huronian.

(3.) *The Marquette iron-bearing rocks belong to a system not yet defined.* If they underlie the Huronian, they equally overlie the Laurentian. They are not separated from the Laurentian by a structural unconformability; but by the evidences of a long intervening lapse of time, and a most important change in the action of the geologic forces. Strata fully crystalline and strata essentially earthy, though found in conformable juxtaposition, must necessarily belong to two different ages and modes of geologic activity. This subject will be more fully treated in the final generalization from my studies in Minnesota.

2. *The Gogebic iron belt.* I shall confine selections from my notes almost wholly to facts illustrating the geology of the range, and supplying a basis for comparisons with the Vermilion Range. At the "south vein" of the Colby mine the ore is an incoherent earthy mass which, for the greater part, is worked out with pick and shovel. It is, however, imperfectly cemented together in irregular patches; and some blasting is required to remove the whole. The general color, before weathering, is dark brown. This deposit is about eighty feet

wide, in a sheet dipping north 50° to 70°, with an average of about 60°. But on the north side the same material extends at this place, to a greater distance. The limiting wall on the south (foot wall) is a compact, hæmatitic slate. Here we notice through a part of the excavation, the continuance of the earthy mass; but beyond this, westward, a broken ferruginous slate succeeds it; and at the western end of the excavation, it approaches the opposite wall, and all the ore is pinched out. Forty or fifty feet of the rock on the south side are broken and in confusion; yet one can trace bedding courses in the lower twenty feet of this. There are no indications whatever of eruptive action.

On the south side the regularity is much interrupted. When the hæmatitic slaty wall is removed, one sees behind it a jumble of rock, masses perfectly promiscuous in position, but mostly hæmatitic. Still, some portions are greenish, amorphous, chloritic, passing down in shapeless masses, bent and arched in a promiscuous way. Some are light colored, sandstone-like masses, simply stained with iron. The iron which pervades all these conditions of rock seems to be simply forced out like fat; and to have accumulated where the action was most intense or where the condition of the rock most favored.

South of the Colby mine, in the cut of the railroad is an outcrop of siliceous argillytes (500), reddish and drab, with dip N. 10° W., and amount 65°. These are interbedded with quartzyte schist. The thickness exposed is 250 feet.

By the railroad near Bessemer, coming from the Valley mine, is an outcrop of conglomerate, with slight dip north. It is a small exposure, but in place, composed mostly of pebbles of dark red sandstone, hæmatite, granulyte and diabase. It appears like a conglomerate at the base of the Kewenian.

At the East Norrie mine, southeast of Ironwood, the open excavation shows simply a confused mass to the depth of a hundred feet. Soft ore is raised from underground workings.

At the Aurora mine the open work shows a general dip north at the usual steep angle. On the south side is a quartzyte which, in decayed situations, resembles the sandrock in the Colby mine. Much excellent soft ore is coming out of the ground here.

By means of observations at the Aurora mine and thence to the hill one fourth mile south, we were able to determine the following sequence, in descending order:

Broken and mixed ore.

Main deposit of ore dipping north at an angle of about 65°.

Quartzyte forming the foot wall in the Colby and Aurora mines.

Siliceous argillyte south of Colby mine—seen 250 feet. This perhaps occupies part of the concealed space south of the Aurora.

Quartzyte and syenite gneiss interbedded, in the hill 633 feet south of the north face of the quartzyte in the Aurora. Thickness, 595 feet.

Syenite gneiss (502) on the hill south of the Aurora.

This syenite is a heavy outcrop. It contains some fragments, mostly of greenstone, and only partly rounded. It reminds me of the Seagull and Saganaga regions, Minnesota. The rock weathers light colored. It is granular and porous, varying to compact. The feldspar is very pale pinkish, and the hornblende is grayish-greenish. It presents all the characters of true syenite, showing no trace of bedding within the area subject to observation. But it is evidently a fragmental rock, since it contains many rolled fragments. It furnishes us ocular evidence that real syenite, with all its proper crystalline characters, may be a rock of sedimentary origin.

Looking around, we discover other evidence of its close affinity with products of sedimentary action. Close by, it overlies a true, fine-grained quartzyte (503). The contact is apparent in several places. Four rods south of this syenite, a considerable mass of quartzyte is imbedded in syenite. Down the hill a few rods further, we find a vertical ledge of gneiss including warped and broken sheets of a siliceous schist. Some conception of the relations may be gained from the following diagram:

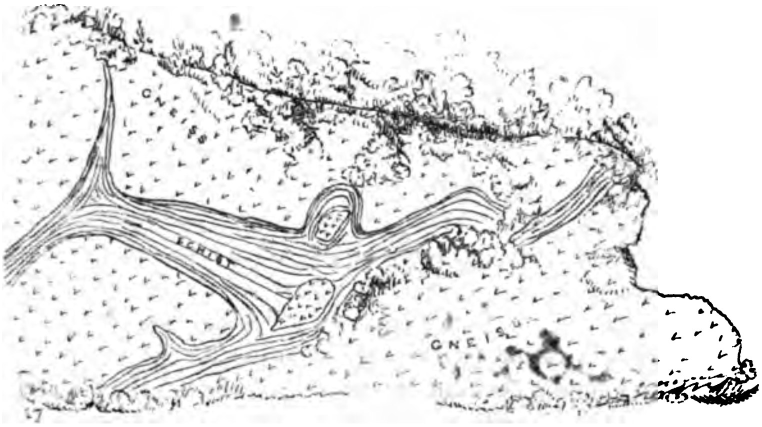


Fig. 17. *Relations of quartz schist and syenite gneiss, Gogebic Range, Michigan.*

This siliceous schist resembles some portion of the slates seen west of Colby mine; and this and the quartzyte spoken of as in contact with the syenite, may easily be the lower portion of that very series of slates.

In the above diagram, the isolated areas of syenite shown in the midst of the quartzyte may be the summits of bosses protruding through from the principal mass of syenite, and not as they appear, small masses wholly detached, and belonging, therefore, to the incidents of a fragmental process.

At the Iron King mine, it is said there is neither any well defined hanging or foot wall. The south country, where explored, is quartzyte, but the hanging wall is "paint rock." We find here two ore deposits. Between the north and south deposits are jasper and quartz and sand rock. The jasper is not red, but "gray-black." The distance between the two deposits is about 400 feet. The south deposit is also about 80 or 90 feet wide; but they have struck no regular hanging wall.

At the First National mine, the distance between the two deposits is 200 to 800 feet, and there is no good footwall on the north deposit

I noticed, about half a mile east of the Iron King mine (1104), close by the road, on the north, that exploring parties had thrown out a quantity of black slate (504) quite unlike any hitherto seen in the region by myself. It has the aspect of the Huronian black slate of Canada; but is strikingly distinct from any seen by me in connection with the iron deposits either of the Gogebic or Marquette region. It would be exceedingly interesting to learn whether this black slate is conformable with the ordinary ore-bearing schists of this range.

The foregoing detached statements from my note-book, must suffice. The evidence renders it probable that the rocks of the Gogebic Range are the geological equivalents of those of the Marquette region. Lithologically, the resemblances are close, and need not be here repeated. Their low position, removed but a few hundred feet from the crystalline rocks, is analogous. They have been subjected, however, to less disturbance; and hence occur in a continuous "range," with dip and order of stratification somewhat uniform. In respect to disturbance, they hold a position intermediate between the rocks of the Marquette and the Vermilion districts; but more resembling the latter. We find here, also, intimations of an overlying system, of contrasted character, and recalling, as at Marquette, the slates of the Huronian.

3. *The Penokee Gap.*—The railway from Hurley to Mellen makes sundry cuts through argillytes of dark and brown color, dipping north ward at an angle of 75° or 80°. One signal instance is less than a mile east of Hoyt. Toward Mellen, we see heavy, blue-black slates dipping N. 56° W. at an angle of 80°.

After the classical study of the Penokee Gap which was completed by professor Irving in 1876, I had no expectation of making any additions to knowledge during my short sojourn there; but I deemed it important to become personal witness of the phenomena which he had described, with a special view to exercising an independent judgment on the question of the equivalency of the Penokee and Gogebic ranges. This question, in view of observations recently made by me in the original Huronian, and in the Marquette and Gogebic districts, had acquired for me a new and special interest. I wished to make a few examinations in entire freedom from prepossessions; and I therefore, dismissed from my mind completely, all recollection of conclusions enounced by the Wisconsin geologists. My notes were recorded exactly as if no other geologist had ever written of the Gap; and what I introduce here will be strictly a few excerpts from my field-book.

Arriving at Penokee station, I proceeded at once to the outcrop about three-fourths of a mile south, and carefully studied northward along the railroad. At the point where I began is a bedded formation dipping S. 22° E. at an angle of 88° to 90°. It consists of interstratifications of pale-reddish and blackish-gray bands. The dark bands (505) range in thickness from one-fourth inch to two feet. The pinkish (504a) are similarly variable, but constitute a large majority of the formation. Where the pinkish attain a thickness over one or two inches, they are intersected by sheets of the darker, and where the darker are of similar thickness, they are laminated by sheets of the pinkish. The darker, besides, are striped by paper-thick sheets of the pinkish; and, in the extreme of attenuation, the latter become resolved into separate grains disposed in planes through the dark bed.

When the dark beds are examined under the lens, they appear composed of a fibrous, almost scale-like, hornblendic mineral, which in places seems passing to mica, or an argillaceous scaly mineral—and with this, generally, more or less reddish orthoclase. So, it is neither hornblende schist nor syenite gneiss; but rather a hyposyenite gneiss.

When the pink bands are examined, they are seen to contain reddish grains of orthoclase and grains of glassy quartz. So they are essentially granulitic gneiss. But the pink rock varies in constitution, first, by admitting a sparse dissemination of the black mineral, then, so much of it as to constitute continuous films; second, by fusion between the quartz and feldspar, so as to form a petrosilex; and third, a fusion of the grains of feldspar by themselves, or nearly by themselves, forming a felsite (506-507).

The alternating bands of pink and dark rock are not entirely persistent, especially, when less than two or three inches thick.

The amount exposed at this outcrop is 30 feet.

Twenty rods north of this place, are beds having the same steep dip —almost vertical—consisting of pinkish, blackish and grayish alternating. The blackish (508) appears to consist of "nascent" mica and quartz grains, with a little orthoclase. It appears like hornblende schist passing to mica schist. This sort predominates. The blackest layers only, contain less feldspar and quartz. The pinkish are about the same as at the previous locality. The gray are the same as the pinkish, except that the orthoclase is white.

In this exposure are some beds very solid, under the lens containing a sort of groundmass apparently of orthoclase and hornblende, and in this, disseminated grains and crystals of some feldspar (508a). It is not a porphyry, nor even truly porphyroid; nor a complete porphyrel; but it approaches the last.

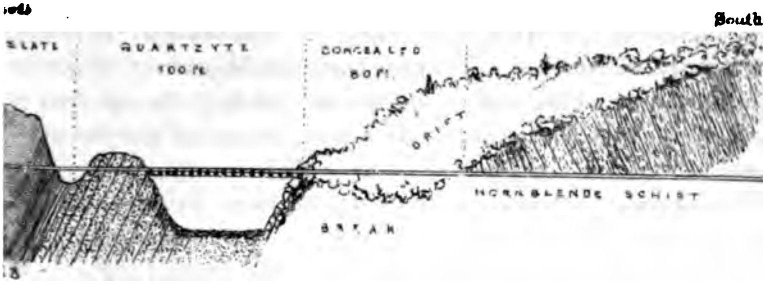
About twenty feet of this exposure are seen. Then the formation is concealed 60 feet; then an outcrop of the same, 10 feet; then concealed 50 feet.

About 125 feet from the last locality, toward the north, the formation dips 79° toward S. 7° E. having beds of alternating porphyrelloid and hornblende schist (509), with also thin beds of muscovite schist. The last contain some hornblende, and the other a little muscovite. Some of the pinkish rock continues in diminished amount. The thickness exposed here is about 180 feet, but the proportion of pinkish beds is in places increased, and the bedding is also in places thinner. The dip diminishes to 71°. For the next 12 rods north the rocks are concealed.

Twenty-three rods still farther north, occurs another outcrop (510) very similar to the last, dipping in about the same direction at an angle of 74°. The formation, however, though dark and dark-gray, contains less of distinguishable hornblende, and much more quartz;

some heavy beds, though so dark colored, are essentially quartz- (511). But others approach hornblende schist, and some contain ny disseminated grains of reddish feldspar. The breadth of this crop is 200 feet. Then the rocks are concealed for 80 feet, to the lge over the Bad river. This is the red truss bridge, and the second lge south of the station.

Jnder the bridge, 300 feet from rock 510, is seen a vitreous quartzyte 2), dipping N. 22° W., amount 62°. The vitreous variety is under north end. That under the south end is porphyritic (513). Here marked unconformity; but the exact junction of the northward- ping with the southward-dipping rocks is concealed. The situation hown in the following cut:



. 18. *The unconformity in the Penokee Gap, Wisconsin. Looking east.*

The last rock seen going north, is at *a*, and it is so massive that no lding can be detected; yet, in immediate contact, south, the dip is th.

Professor Irving reports limestone under the south end of the bridge, t I did not observe it. A thin bed may occur there.

Three hundred and eighty-three feet from the southern limit of this artzyte is an outcrop of dark siliceous slates (515), thin bedded, and ch jointed, dipping N. 25° W., amount 64°. They are highly silice- toward the bottom, and more argillaceous above (516-518). In ces, they are in compact beds four or five inches thick; in places, y become thin-laminated, and occasionally crumbling. They are exact representation of portions of the Animike slates. The bed- g on the whole, is very true, but there are occasional kinks and nges in dip. These slates are seen for 42 paces—126 feet—; then es a concealed place, for 75 paces—225 feet.

The next outcrop (519), ten rods north of the bridge nearest the station on the south, is decidedly flinty or jaspery, and the beds contain a large percentage of iron. Though distinctly stratified, this outcrop is as hard and slippery on the polished surface, as a boss of steel. The outcrop is seen for fifty feet. In a position stratigraphically 10 feet above this, on the hill-side, is an exploratory shaft. It is carrie down on the dip, and a large amount of rock (520) has been throw out which is heavy with magnetite. But obviously, the experimen was made without knowledge. We have therefore, so far, 150 feet o magnetitic schists. The same formation, with diminished amoun of magnetite, is traceable 200 feet from the locality by the riv bank.

At a point five rods north of the railroad tank at the station, t iron formation is succeeded by black argillytes (521), also a perfe reproduction of the Animike. They are thin-bedded, little siliceo and strictly undisturbed. They are traceable 34 paces—102 feet—th comes a concealed interval of 168 paces—504 feet—to the first brid north of the station. About half a mile beyond this is the next o crop.

This outcrop is ten rods north of the third bridge north of t Penokee station. It consists of black carbonaceous argillytes (5 similar to 521, but a little more siliceous, and containing a multit of small dark spots or specks of about the hardness of the slate. T specks weather out, leaving little cavities. The dip is here 64°, tow N. 23° E. The length of the exposure is 158 paces, equal to 474 fe This is along the railroad, which runs N. 25° W. Hence the d tance across vertically would be by trigonometrical calculation, 3 feet.

If the thickness this side of the bridge is 363 feet, and the sa slate continues under the half mile interval north of the bridge same angle of dip—giving, say, 1,760 feet, then the whole thickn of the slates would be

Magnetitic slates, (519)		2
Black argillytes exposed	102	
Black argillytes concealed, to first bridge	504	
Black argillytes concealed north of bridge	1,760	
Black argillytes, (522)	363	
		2,7
Magnetitic slates		10
Total		3,0

The 100 feet of magnetitic shists indicated above are the last part of the outcrop 522. Here numerous test pits have also been opened, but also without success, as might have been expected.

Beyond this outcrop I examined along the railroad about a thousand feet, and found no other exposure. The needle, of course, becomes very unreliable in this cut—varying to the extent of 50° one way and the other.

In this large cut north of the station there is much more physical disturbance revealed than in the one south of the station. In one place, the continuity of the strata is completely interrupted for a space of six feet on the east side; and on the west side, a disturbance such as indicated below has taken place.

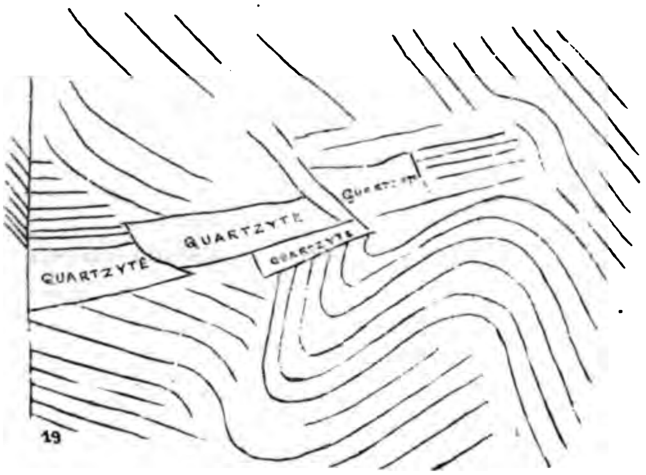


Fig. 19. *Contortions in the magnetitic schists at Penokee Gap, north of the station.*

Bringing the various observations into correlation and aggregating, it appears that we find in Penokee Gap 988 feet of strata dipping south and 3,480 feet dipping north. These figures, of course, do not indicate total thicknesses of formations.*

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* The results of professor Irving's work in the vicinity of Penokee Gap may be found in the *Geology of Wisconsin*, vol. iii, pp. 94-5, especially. Atlas sheet xxiii. Plate xiii is a view of the second bridge south of the station Particular descriptions of the rocks follow.

The firmly accepted conclusion of the Wisconsin geologists in reference to the equivalency of the magnetitic and carbonaceous slates of the Penokee Gap makes them a continuation of the hæmatitic schists of the Gogebic range. That is, they hold the formation in both regions to be Huronian. That the Gogebic iron-bearing strata are not Huronian, I feel prepared to affirm. And I cannot resist serious doubts of their equivalence with the Penokee strata, which strongly impress me as holding characters strikingly similar to those of the Huronian slates of lake Huron and the Animike slates of Gunflint lake and Thunder bay. This resemblance impressed me from the beginning; but I feel reluctant to controvert the judgment of the Wisconsin geologists.

But while I hold the decision in abeyance, I take the liberty to offer a few points for consideration:

(1). We discover the strong lithological resemblance referred to.

(2). The lithological characters are unlike those of the ore-bearing strata of the Gogebic, Marquette and Vermilion regions.

(3). The ore also is magnetic instead of hæmatitic.

(4). It is diffused through the laminated sheets of the formation, as at Gunflint lake, and not segregated in lodes, as in the other regions mentioned.

(5). A higher system of black slates, apparently unconformable on the hæmatitic schists, appears to exist in the Gogebic and Marquette regions, as it certainly does, in the eastward prolongation of the Vermilion schists.

(6). At the distance of 15 to 18 miles in a direct line S. S. E. of the Gogebic range, is a well known line of magnetic attractions, such as are exerted by the magnetitic schists of Penokee Gap.

(7). These lines of attraction, though as far as I know, they lie too far south, may nevertheless, when more accurately located, be found in the strike of the Penokee schists, especially if the great exposure a mile north of Penokee station affords a reliable indication of the strike; for that is S. 67° E. But this is probably disturbed somewhat by the great fault.

Should the Penokee slates be identified with the Animike (true Huronian), then the Marquette or Kewatin system, will be found underlying, and the juxtaposition of the Penokee slates with the (supposed) Laurentian schists on the south, may be due to an overslide accompanying the formation of the great fault. If the dislocation resulted from a horizontal movement, instead of an upthrow, then the strata on the east side must have slipped southward over 900 feet; and, if the movement was confined to the Penokee slates, they may thus have concealed a thin representation of the Kewatin which, on the identification assumed, is at present, wanting at this point.

§ 4.—OBSERVATIONS BETWEEN TOWER AND PSEUDO-MESSER LAKE.

On the portage from Mud lake to Burntside lake a fine-grained graywacke appears on the hill (523).

This formerly very bad portage, referred to in my report for 1886, has been improved by laying timbers lengthwise along the path through the long swamp. But the execrable portage on Mud creek has received no improvement whatever.

I embraced the present opportunity to complete my line of observations on the northwest shore of Burntside lake. (See Rep. 1886 pp. 37 and 206.)

N. W. ¼, S. W. ¼, sec 30, T. 63-13 Burntside lake. Graywacke schist continues, but here much intersected by veins of granite.

Island, N E ¼, S. E. ¼, sec. 30, T. 63-13. Mica schist and gneiss interbedded. The schist also is much veined with gneiss.

N. W. ¼, N. E. ¼, sec. 30, T. 63-13. Main land north side. Gneiss and mica schist, but mostly gneiss. The schist is exceedingly fine-grained.

North point of small island, S. E. ¼, S. W. ¼, sec. 20, T. 63-13. Good muscovite schist.

North end of long island, N W. ¼, S. W. ¼, sec. 21, T. 63-13. Nascent mica schist. No mica distinctly formed, to the naked eye; but under the lens it comes out unmistakably.

The general tenor of the rock formation from here all around the north side of Burntside lake is indicated in the preceding observations. Most of the islands in the lake are of the same character. The outlet of the lake only, at the west end, and its immediate vicinity lies to the south of the great crystalline masses.

Proceeding eastward we find the portage from Long lake to Fall lake presenting near its eastern end, a remarkably bad condition. The last twelve rods are literally under water except at low stage.

At north end of portage from Newton to Fall lake the prevailing character of the rock is as stated below; but this is quite different from that before seen in this vicinity. It is the old "talcose slate." (979.)

At Pipestone rapids at the entrance to Basswood lake (*Report*, 1886, p. 104) the quartz mass exposed last year in the middle of the stream was now found completely submerged and the water covered the broad beach on the east side below the falls, quite up to the high bank. The volume of water appeared to be twice as great this year as it was last year in the same month.

Rock 524. Chlorite rock—"pipestone" from Pipestone rapids.

N. E. ¼, S. E. ¼, sec. 6, T. 64-10. At end of portage from Arm IV to Arm II, Basswood lake. The syenitic gneiss here contains many half rounded grains of nearly white feldspar; but the rock has a dark gray feldspathic groundmass disposed in a bedded manner. This itself apparently consists of finer particles of the same feldspar, with a decaying chlorite-like mineral. There is no hornblende present here. The rock is chlorite gneiss.

Proceeded over portage from Arm II to Arm III and by north side of the large islands in Basswood lake.

S. W. ¼, S. W. ¼, sec. 32, T. 65-8, as of Minnesota. North side of Sucker lake. The rock is a felsitic argillyte (525), hard and ringing, tending to split into thin laminæ. Thin scales are waxy-translucent. Many joints cross the vertical bedding.

The temperature of the air at 7 A. M. (Aug. 8) was 50° Fah. The lake was steaming, with a temperature of 57° near shore and 68° remote from shore.

The slate at portage out of Sucker lake is a dark argillyte. On Melon lake, the rock is also translucent on thin edges.

§ 5 —PSEUDO-MESSER LAKE.

Pseudo-Messer lake lies mostly north of the accepted boundary; though the canoe route commonly pursued passes through most of its longitudinal extent, and by the terms of the treaty fixing the international boundary, nearly half of the lake would seem to fall on the American side. The southwestern end of the lake rests on the boundary as recognized, and connects with Sucker lake on the west, and with a series of three small lakes on the east which lead into Knife lake (*Rep.* 1886, p. 142). The usual portage approach from Knife lake starts from the north shore at N. E. ¼, N. E. ¼, sec. 30. T. 65-7, (as of Minn.) and proceeding over a hill reaches a Canadian lake about a mile in length. A portage of twenty-five rods leads from this to Pseudo-Messer. The shores of the last mentioned are mostly surrounded by cliffs of slates presenting the usual appearance of the neighborhood of mica and hornblende schists; but the schists do not touch the shore even at the most northern point. The shore line is very irregular, rendering canoeing difficult, and toward the southern extremity are narrows located close to the east main shore.

S. E ¼, S. E. ¼, sec. 19, T. 65-7, (as of Minn.) On the portage north from Knife lake. Slates of dark color several times outcrop. The structure is nearly vertical and strikes N. 78° E. I looked carefully for bedding planes unconformable with this structure and found none.

N. W. ¼, S. E. ¼, sec. 19, T. 65-7, (as of Minn.). Near north end of portage. Gabbro occurs in a low exposure of 4 feet (974) and about 20 feet above the Canadian lake.

N. E. ¼. N. E. ¼, sec. 24, T 65-8, (as of Minn.). At end of portage from Canadian lake to Pseudo-Messer. Here are signs of approach to mica schist (975).

Believing the boundary of the crystalline schists to exist in the near vicinity, I made an excursion to the northern extremity of the lake.

S W. ¼, sec. 13, T. 65-8, (as of Minn.). North part of Pseudo-Messer lake, west side. The rock here (976) is a rough-weathering slate having the appearance and approximately the constitution of the chloritic rock at Kawasachong Falls (*Rep.* 1886, pp. 58, 60)—by some supposed eruptive

N. W. ¼, sec. 13, T. 65-8, (as of Minn.). Extreme north bay of Pseudo-Messer lake, The rock here preserves a similar aspect to the last. On islands near, it contains iron. Here is a cascade falling into the lake.

Rock 977. A sort of porphyrel.

Rock 978. Micaceous green rock, passing into the red rock of Kekequabic lake. Found on portage, not in place.

§ 6.—KNIFE LAKE (See *Rep.* 1886, pp. 142-4.)

Revisited eastern end of portage from Potato to Knife lake Dark vertical slates (526) are here seen, varying from carbonaceous argillyte to siliceous and red jaspery schists excessively convoluted with bands of hæmatitic schist sometimes quite rich.

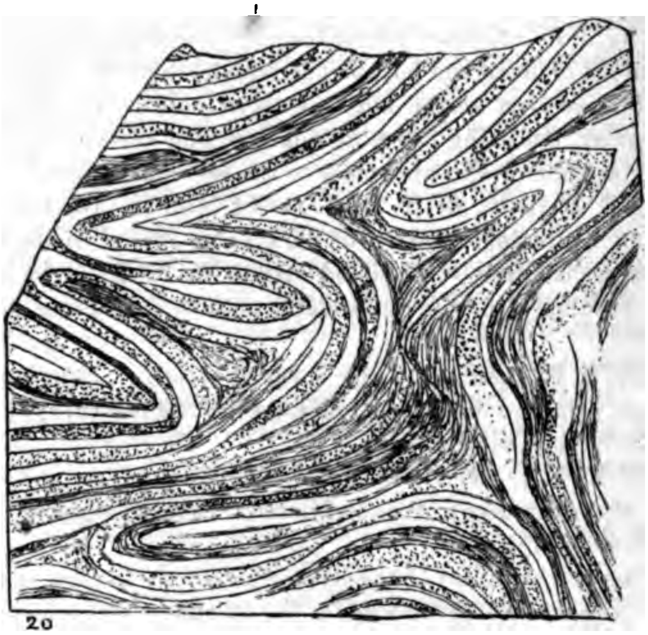

Fig 20. *Convoluted, jaspery and argillitic slates, west end of Knife lake.*

Similar slates continue eastward to Mokoman island, where they stand on edge and strike N. 72° W. They split into very thin leaves —even a sixty-fourth of an inch thick.

Arm IV (Knife lake).

N. W. ¼, N. W. ¼, sec. 27, T. 65-7, Knife lake, Arm IV. Very siliceous slate (527), not splitting readily. This is not felsitic. In color it is blackish-gray.

N. W. ¼, N. W. ¼, sec. 26, T. 65-7. Siliceous slate near the shore, compact and ringing, weathering white. Farther back, less hard, more slaty, composed of interstratifications of slate-colored bands and greenish bands. The latter are in places much bent and folded. The lighter bands weather poroditic in aspect, but they are really slaty within.

Rock 528.	Flinty argillyte.
Rock 529.	Siliceous argillyte.
Rock 530.	Greenish bands in last.
Rock 531.	From a bowlder.

N. W. ¼, S. W. ¼ sec. 24, T. 65-7, Arm IV, Knife lake. An outburst of diabase trending east and west, and forming a broad promontory on the south side of the Arm. The opposite shore appears to be slate.

S. W ¼, S. E. ¼, sec. 24, T. 65-7. Siliceous slate.

S W. ¼, S. E. ¼, sec. 24, T. 65-7. Large outcrop similar to that of rocks 528-530. The lighter-weathering beds, however, assume a conglomeritic structure—lumps of hornblende impacted in an argillo-feldspathic groundmass and weathering conglomeritic and very rough (533). But this is not the character of the Ogishke conglomerate. (Compare Rep. 1886, p. 412.) Rock 532. From the more compact and diabasic part.

S. W. ¼, S. W. ¼, sec. 19, T. 65-6. The same formation continues.

S. W. ¼, S. E. ¼, sec. 19, T. 65-6. Felsitic siliceous schist (534), hard and compact, pale greenish.

S W. cor. sec. 20, T. 65-6. Felsitic siliceous schist.

N. W. ¼, S. W. ¼. sec. 20, T. 65-6. Mixture of diabasic slate and argillyte (535).

The rapids from Epsilon lake on the south can be seen descending a slope apparently 75 feet.

American Giessbach, N E ¼, S. E. ¼, sec. 20, T. 65-6. The formation here is a true argillyte. Crossed the portage here and looked into Epsilon lake (see § 33, Epsilon lake). Its surface is but ten feet below the crest of the dividing ridge at this point.

S W. ¼, N W. ¼, sec 21, T. 65-6. The rock approaches the character of the Stuntz island conglomerate in Vermilion lake.

This south bay or bifurcation of the IV Arm of Knife lake is surrounded by wavy topped and barren hills, reaching altitudes of 100 to 150 feet and over. They present precipitous faces toward the lake, often assuming a rude columnar aspect.

N. W. ¼, N. W ¼, sec. 22, T. 65-6. Stuntz conglomerate. It contains no foreign pebbles, but only pebbly forms, especially on weathered surfaces, which seem to be little different from the general mass, and beneath the surface are merged undistinguishably in it.

N. W. cor. sec. 22, T. 65-6. Good dark argillyte (536) exactly like that at east end of Sucker lake.

N. E ¼, N. E. ¼, sec. 21, T. 65-6. Felsitic argillyte (537), but approaching Stuntz conglomerate.

Memorandum. The Tower iron-mine blasts are audible here, a distance of 58½ miles in an air line, but nearly along the strike of the rocks. After many observations on these sounds during two seasons, I am convinced that the crust of the earth is the medium of transmission of the vibrations which at this distance produce the sensation of sound. But I have never noticed any second report transmitted through the air. I have remarked, however, that the sounds are transmitted to a greater distance *in the direction of the strike* than in a direction across it This fact accords with observations on the transmission of seismic disturbances.

N. E. ¼, N. E. ¼, sec 20, T. 65-6. Stuntz conglomerate (538)—the constituent pebbles giving a faint porphyritic appearance.

S. E. ¼, S. E. ¼, sec. 17, T. 65-6. Rock (934) quite argillitic but the sedimentation lines are distinctly conformable with the schistic.

N. E ¼, N. E ¼, sec. 17, T. 65-6. Finely porphyritic schist (935).

N. E. ¼, S E. ¼, sec. 17, T. 65-6 A low entirely massive exposure of a rock (936) of porphyrelloid aspect, containing striated feldspar.

N. E ¼, S. W. ¼, sec. 16, T. 65-6. Noryte, same as "Pulpit rock" noryte. Rocks 926-9.

Rock 937. Pulpit Rock noryte.

A few feet north of this appears a gray felsitic slate (938), having the aspect of the Vermilion slates, but the dip of Animike. The dip is southward 53° in a direction S. 20° E.

Searching to the top of the hill for vertical schistosity I found it, but the rocks are argillytes—black and gray interlaminated (939 Kewatin series?).

N. E. ¼, S W. ¼, sec. 16, T. 65-6. Gray feldspathic rock (940), similar to 938, but it contains angular fragments of black siliceous argillyte.

N. W. ¼, S. W. ¼, sec. 16, T. 65–6. Near the point.

Slate. Banded argillyte (941), with dip of 71° toward the S. 35° E. —the sedimentary structure corresponding with the schistosity. Supposed of the Kewatin series.

N. E. ¼, S. W. ¼, sec. 16, T. 65–6. In the narrows, south side.

Here a rock-mass apparently schistose vertically, but in quite a brecciated state, stands between two masses without discoverable schistosity. The one at the point shows structure-lines running but little east of north, with vein-like forms, but no true veins, and these faulted. This mass is only less brecciated in structure than the middle one; and I find some pebble-like portions isolated from the general mass. On the whole I shall set the rock down as Stuntz conglomerate. The formation weathers exceedingly rough. Rock 942.

S. W. ¼, N. E. ¼, sec. 16, T. 65–6. Flinty argillyte, dipping about south at an angle of 25°. There is no schistosity separate from the sedimentation (943). Query, is this Animike?

S. W. ¼, N. E. ¼, sec. 16, T. 65–6. Stuntz conglomerate forms the whole point.

N. E. ¼, N. E. ¼, sec. 16, T. 65–6. A mass of porphyritic character, having a granular feldspathic base and feldspar crystals. It is similar to Rock 936.

N. W. ¼, S. W. ¼, sec. 15, T. 65–6. In the southward bay, west side. Same sort of porphyritic rock. The cliffs rise majestically around the shores of this bay.

N. E. ¼, S. E. ¼, sec. 16, T. 65–6. A perpendicular bluff fifty feet high, broken in sub-columnar forms. It is still the porphyrelloid rock, closely related to Stuntz conglomerate.

The same formation uprises at the extremity of the bay, and walls in nearly all the southeast side.

S. W. ¼, S. W. ¼, sec, 15, T. 65–6. Inland, south of head of bay.

A lofty hill which at shore, is quite conglomeritic, but back from shore is scarcely more than the porphyrelloid rock so abundant. No certain schistic or bedding structure can be seen, but there is an ambiguous structure running N. 20° E. From such observations it appears that the Stuntz conglomerate, porphyrel, porphyrellyte and porodyte sustain close relations of structure, composition and genesis; and actually graduate into each other. The schistic condition of the porphyrellyte and the fragmental character of the conglomerate, appear as reminiscences of a sedimentary origin; while the massive porodyte and generally unbedded porphyrel reveal the nature of the changes to which all have been exposed.

Rock 944. Groundmass of Stuntz conglomerate.

S. W. ¼, N. W. ¼, sec. 15, T. 65–6. Mouth of little bay, east side. The porphyrel is cut by a dike of diabase (945) 30 feet wide, dipping 85° northward, and trending N. 42° E.

Porphyrel continues to the eastern end of this northern bifurcation of Arm IV, Knife lake I do not make out any distinct system of bedding or schistosity. The rock-masses are rough, rugged, lofty and structureless; obscurely, however, there exists a series of vertical, but very irregular divisional planes, giving rise to rough and rude columnar and pyramidal forms; but every feature is irregular.

N. E. ¼, N. W. ¼, sec. 15, T. 65–6. A great boss of the same rock indenting the head of this Arm.

N. W. ¼, N. W. ¼, sec. 15, T. 65–6. A perpendicular bluff 100 feet high, which, from the fragments thrown down, appears to be irregularly bedded slate, some of which is bluish and some blackish.

N. E. ¼, N. E. ¼, sec. 16, T. 65–6. Porphyrel appears densely and neatly porphyritic.

The high range of bluffs along the north shore of the north bifurcation of Arm IV, as far as the narrows, is all formed by porphyrel, varying little in external aspect or internal structure. No schistosity is disclosed. Some of the bluffs present a wild and picturesque appearance.

S. E. ¼, N. W. ¼, sec. 16, T. 65–6. A high vertical bluff, a little different (945 bis). It is finely porphyritic, with a feldspathic groundmass, and inclosing slivers of dark argillyte.

S. E. ¼, N. W. ¼, sec. 16, T. 65-6. Slaty argillyte (946), mostly dark color, with schistosity and sedimentation planes dipping 73° toward S. 70° E.

S. E. ¼, N. W. ¼, sec. 16, T. 65–6. An enormous vertical mass of slaty material dipping 57° S. S. W. The sedimentary banding coincides. The slate is mostly dark, roughish argillyte interbedded with granular, grayish argillyte. Some portions have the hardness and fracture-look of diabase; but they are not truly diabasic.

Memorandum. I saw here a strawberry flower, and a ripe Alpine strawberry on the same stem—Sept 16.

S E. ¼, N. W. ¼, sec. 16, T. 65–6 A mass of slate dipping 55° toward S. 25° W., and intersected by a diabasic dike 15 inches thick, dipping 30° toward N. 25° E., and therefore, almost exactly at right angles with the slate.

Rock 947. Diabase from dike.

Rock 948. Slate in immediate contact.

Rock 949. General character of the slate.

Rock 950. Coarse material interbedded.

Rock 951. Fine dark diabase-looking rock.

Rock 952. Conglomeritic or brecciated portion of formation with many grains of glassy quartz.

The highest rock is 951.

Similar rocks form the entire promontory which faces the little bay on the north shore On the north side of the bay the dip is about 80° south. For the next third of a mile, the shore is lined by large hills having the same aspect as these.

N. E. ¼, S. E ¼. sec. 17, T. 65-6. Chloritic argillyte (953), very irregular in structure and rough in weathering.

S. E. ¼, S E. ¼, sec. 17, T. 65-6. Black siliceous argillyte (539). The banding is conformable with the schistosity.

Glacial striæ S. 19° W.

There is no sign of a human being along these shores. The forest is primeval; the ancient moss clothes the ground.

Sleeping all night within sound of the roaring falls from Epsilon lake, I determined to visit them and obtain a photograph if practicable. I find the falls the finest that I have yet seen in northeastern Minnesota. There is a descent of at least 75 feet, down one continuous but broken slope, at an average angle of about 45°. I took three negatives under considerable difficulties, all of one scene about two-thirds the way down. A view of twice the length of cascade is glimpsed higher up, but a clump of ceders forms too serious an obstruction to chop away. The falls are visible from the lake, and present so much the aspect of the falls of the Giessbach from the lake of Brienz in Switzerland, that I propose to name these the American Giessbach. This bifurcation of the IV Arm is also of nearly the dimensions of the lake of Brienz, and is surrounded by a similar rampart of ancient rocks.

S. W ¼, N. E. ¼, sec. 20, T. 65-6. Island near north side in front of the Giessbach. The slate hills on the north, with their steep fronts present from here a very impressive view, and I took a photograph.

S. E. ¼, S. E. ¼, sec. 17, T. 65-6. Stuntz conglomerate. The course now passes along the north shore of the IV Arm.

S. E. ¼, S. E ¼, sec. 18, T. 65-6. A high and massive bluff of the nondescript sort of rock (540), which has heretofore been denominated Graywacke.

S. W. ¼, S. E. ¼, sec. 18, T. 65-6. An enormous talus fallen from a high bluff. Fine, bluish, dark rock (541), without conspicuous quartz, and looking somewhat like very fine diabase; but I think it a phase of the graywacke last seen.

N. W. ¼, S. W. ¼, sec. 24, T. 65-7. Graywackenitic rock (542), but a little more slaty in aspect than the rock 541.

Arm III (Knife Lake).

S E. ¼, N. E. ¼, sec. 23, T. 65-7. Portage from Arm IV to Arm III, Knife lake. The two arms are separated here by about forty paces, and we portaged over, with a view to working eastward toward Saganaga lake. No rock is in place on the portage, but I saw large bowlders of Stuntz conglomerate (543) and of graywacke. The conglomerate is obscurely porphyritic.

S. E. ¼, N. W. ¼, sec. 23, T. 65-7. Mouth of Arm III, Knife lake. Island Rock with a sub-slaty structure, breaking into cuboidal fragments, hard, with a slightly graywackenitic aspect, but on close inspection, proving to be a compact, siliceous slate. The sedimentary structure coincides with the slatiness.

Body of Knife lake.

S. W. ¼, S. W. ¼, sec. 14, T. 65-7. Flinty argillyte; but while the beds seem fixed and rigid in direction, ***there are convoluted bandings,*** indicating an original sedimentation-structure ***unconformable with the schistosity.*** The films limiting the bands are nearly black, while the bands are grayish-black and weather dark gray, with the aspect of a compact quartzyte. In thin section, under the microscope we find a very fine granular quartz base with many minute disseminated grains of a black opaque substance appearing anthracitic. In all these features it approximates the flinty schists of Gunflint lake, to be described hereafter. This very dark siliceous schist is represented by rock 544.

S. W. ¼, S. W. ¼, sec. 14, T. 65-7. This is only an eighth of a mile north of the last, but the rock (545) presents much the appearance of the Stuntz conglomerate.

S. W. ¼, N. W. ¼, sec. 14, T. 65-7. Island opposite mouth of Arm II, Knife lake. Sericitic felsitic schist (546) rising 75 feet above the lake.

N. W. ¼, N. E. ¼, sec. 14, T. 65-7. Mouth of Arm II, north side. Porphyritic Stuntz conglomerate; rock 547.

Arm I (Knife lake).

S. W. ¼, S. W. ¼, sec 12, T. 65-7. Bear Narrows, entrance to Arm I, Knife lake. Siliceous argillyte.

S. W. ¼, S. W. ¼, sec. 12, T. 65-7. Siliceous argillyte (548), massive, dark. Strike N. 72° W.

The strait into Arm I of Knife lake is two rods wide, swelling in the middle, and a perceptible current flows out.

N. W. ¼, S. E ¼, sec. 12, T 65-7. On my first visit to this locality the rock was set down as "poroditic" and obscurely porphyritic.

Rock 549. Poroditic porphyrellitic rock.

On my second visit to the locality, I made the following observations: This rock, which is the same as I have seen in many places, especially around Knife lake, is closely related to porphyrel. (For use of term see Report for 1886, p. 159). It not only consists mainly of the groundmass of porphyrel, as I have seen it in Arm IV of Knife lake, but there are clear evidences of the incipient emergence of feldspar crystals from the mass. Thin scales possess a waxy translucency, and the whole base looks felsitic, but it is not hard enough for this, though what I have called felsitic schist, from Sucker lake eastward, is sometimes closely similar. I am unable to form in the field, a final opinion respecting its nature. It requires investigation. From macroscopic study I should say it is composed of argillaceous matter, feldspar and silica in varying proportions, with indications of a magnesian mineral. Perhaps it is parophitic. It seems to form essentially the groundmass of what I have called porphyrel, and for the sake of understanding myself, I will hereafter call this *porphyrellyte.*

This rock I think generally nearly destitute of free quartz, but sometimes I am sure quartz grains are present. When they give a marked hardness to the rock, or when a fine siliceous constituent causes the rock to abrade steel, it may be qualified as *siliceous porphyrellyte.* If argillaceous matter is also present, resulting in a moderate hardness, though free quartz be present, the rock may be characterized as a *graywackenitic porphyrellyte.*

Rock 954. Porphyrellyte from N. W. ¼, S. E. ¼, sec. 12, 65–7.

Rock 955. Slaty porphyrellyte. (Slatiness not much seen in this specimen.)

S. W. ¼, N. W. ¼, sec. 7, T. 65–6. A stupendous vertical cliff (956) at the lake front of a hill composed of what I have designated siliceous porphyrellyte.

N. W. ¼, N. W. ¼, sec. 7, T. 65–6. This point is composed of rock very similar to rock 954; but with somewhat the aspect also of the porodyte of Vermilion lake.

Rock 550. Poroditic porphyrellyte (provisionally).

N. W. ¼, N. W. ¼, sec. 7, T. 65–6. A good typical outcrop of the so-called porphyrellyte. Rock 957.

At this place I find fragments left by some other person, of a conglomerate possessing interest. The groundmass is a siliceous porphyrel, but the rock holds also rounded pebbles of a very dark color, apparently amorphous hornblende, and also pebbles of dark fine diabase. Yet the rock is not Stuntz conglomerate as seen in this region. It is, however, similar to Stuntz conglomerate seen on islands in Vermilion lake.

Rock 958. Conglomeritic porphyrel.

N. E. ¼, N. W. ¼, sec. 7, T. 65–6. On the northeastern shore of a small bay setting from Knife lake, First Arm. The land rises steeply to the hight of seventy-five and one hundred feet, and presents near the summit, as seen from the water two or three abrupt precipices. At the base of the hill, the formation is porphyrellyte (Rock 959). After an ascent of about 40 feet, gabbro is seen, quite characteristic, in arrying magnetic iron ore. It has a vertical thickness of at feet. At the summit I was able to trace an abrupt break n the gabbro and the porphyrellyte. The line of junction traced surface, is shown on the following diagram:

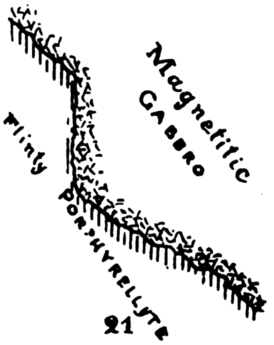

Fig. 21. *Junction between gabbro and porphyrellyte, Knife lake.*

The gabbro along the line of junction is magnetic; the porphyrellyte, flinty.

The relations here existing seem to indicate that the gabbro is an overflow over an old, already denuded surface.

Rock 959. Porphyrellyte from base of hill.
Rock 960. Gabbro with magnetite.
Rock 961. Flinty porphyrellyte, in contact with gabbro.
Rock 962. Magnetitic gabbro in contact with porphyrellyte.
Rock 963. Gabbro of prevailing character.

About twelve feet north of this line of junction, I find another. The porphyrellyte is the same mass as the other. The line trends differently; but this depends undoubtedly on the configuration of the porphyrellyte surface.

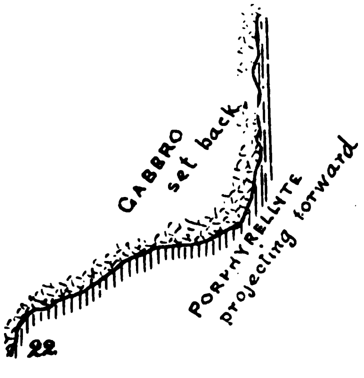

Fig. 22. *Another junction between gabbro and porphyrellyte, Knife l*

I find other lines of junction in exploring the summit of the hill northward. All the junctions are irregular whether traced vertically or horizontally. No appearance of a dike-form is seen. It is as if there had been a rough and irregularly rounded surface over which the gabbro had flowed. My conception of the relative positions of the gabbro and slate is represented by the following diagram:

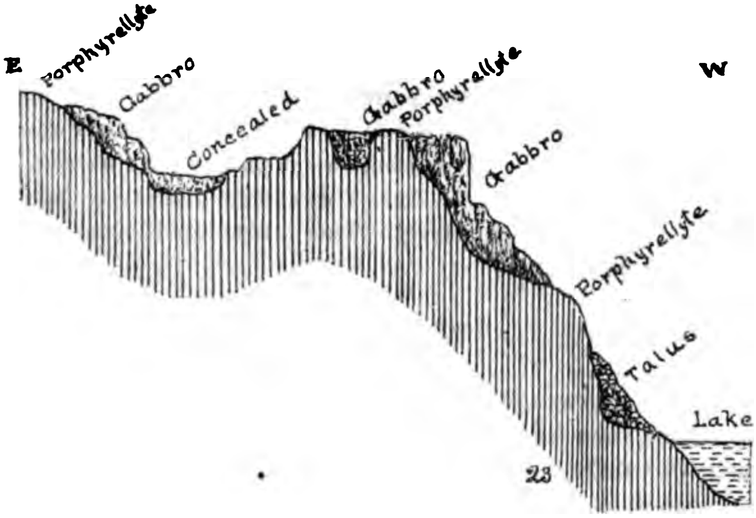

Fig. 23. *Relation of the gabbro and strata at* N. W. ¼, sec 7, T. 65-6 W., Knife lake. Section east and west.

Continued my observations in the contiguous hill still farther northward, and found the two formations alternating with a kind of irregularity entirely suggestive of the explanation embodied in the above diagram.

Extended the examination to the northern and highest hill. This mass is all porphyrellyte, in most parts somewhat slaty. It presents on the westward facing cliff, a rude columnar appearance.

It is not apparent why the gabbro should remain just here, and not be known on other parts of Knife lake so far examined—for I have seen nearly all the Minnesota shores of the lake. Of course, this apparent absence may result from insufficient investigation. It is also, an interesting question, why here, the highest summit is not covered, while the two lower ones are partially covered. Has the gabbro been denuded? or was this latitude above the level of the flow?

N. E. ¼, S. W. ¼, sec 6, T. 65-6. Porphyrellyte like 550 and 957-8, somewhat poroditic in aspect. Rock 551.

Portage eastward out of Knife lake. N. E. ¼, S. W. ¼, sec. 32, T. 66-6. Porphyrellyte—552.

S. E. cor. sec. 31, as of Minn., Canada. Siliceous slate, standing vertically, *with sedimentary structure corresponding.*

Coursed along the entire Canadian shore of this (First) arm of Knife lake.

S. E. part of sec. 1, T. 65-7, as of Minnesota. Porphyrellyte. Found along this Canadian shore nothing but siliceous slate and porphyrellyte in conditions more or less slaty.

At Bear narrows, the western entrance to Arm I, a line of rounded detached rock-masses extends across the strait. Geologically speaking it is not long since there existed here a continuous rock barrier, with only a cut for the drainage. Arm I was then a separate lake, and may have stood at a higher level. There were rapids then, connecting with the main lake.

Body of Knife lake.

From Bear narrows pursued the windings of the north or Canadian shore of the main lake, and laid them on a township plat. I thought perhaps this shore would extend to the crystalline schists; but it does not.

At the most northern point of Knife lake, Canada, the formation is gray, semi-argillaceous slate (964), distinctly but irregularly bedded

Slates varying from gray to dark, extend along the whole Canadian shore of the body of Knife lake. They rise in rounded hills from 100 to 200 feet in hight, presenting some deep intervening gorges and percipitous escarpments facing the lake. They are partly covered by small spruce and Norway pines, which have generally escaped the destructive burnings of the Minnesota side. The shore line is deeply and irregulary indented by bays, and cut by lofty and massive headlands and promontories stretching from a third to half a mile into the body of the lake.

S. E. ¼, S. E. ¼, sec. 21, T. 65-7. Knife lake promontory, west end. This is a bold and conspicuous head-land, as seen from the western part of the lake in sections 21, 28 and 29. It is narrowly connected with main-land at the eastern extremity where we made a portage from the Fourth to the Third Arm. Its main mass is 150 to 200 feet high and has been denuded by fire.

I first examined the second point from the north on the weathered face of the promontory. To my surprise, the rock found here is gabbro (963). It rises up from beneath the water-level, and continues uninterruptedly to the summit.

North of this rises a higher hill, with an escarpment also facing west. Between the two is a depression. I walked across to the high hill. At the commencement of the slope I found a greenish gabbro-slate (966) with grains of quartz-like hardness (olivine?)

To this succeeds a highly olivinitic (?) granular rock 967, consisting of rounded glassy olivine (?) grains imbedded in a gray-feldspathic matrix, breaking irregularly, and presenting on the fresh surface, many reflecting surfaces, and only partially a gabbrolitic aspect.

Quite at the summit of this northern hill, the rock is a coarse-grained greenstone (968). In tracing it eastward, however, along the promontory, it soon passes to gabbro again.

I find the surface presenting a succession of imbricating beds, about twenty inches thick, dipping northward at a low angle as shown below:

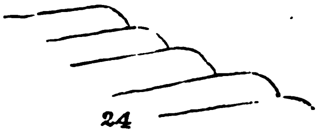

Fig. 24 *Imbricating beds of gabbro, summit of Knife lake promontory. Dipping northward.*

This feature suggests a succession of overflows from the south. The phenomenon is identical with that seen on the summit of a high head-land in lake Gabimichigama. See Halt 840, p. 171, Rep. 1886.

Within half a mile, I find gabbro with considerable magnetite. The rock also changes to a variety with a large proportion of white feldspar.

Rock 969. Magnetitic gabbro. Knife lake promontory.

Rock 970. Gabbro with white feldspar, Knife lake promontory. Here is a bluff of gabbro facing east, and a lower level of the promontory. I *presume* this is the place where the gabbro ends eastward; but I did not go down to the brush-covered level below.

Gabbro continues from the summit of the highest bluff down to the water's slope and below.

Rock 971. Gabbro from base of north bluff.

Rock 972. Purplish gabbro with much glassy olivine.

Took photograph of this promontory from a spot on the Canadian shore.

At the portage out of Knife lake, northward is a siliceous schist of dark color, almost pure flint. Rock 973. See further under Pseudomesser.

§ 7.—OTTERTRACK AND OAK LAKES.

Ottertrack lake lies wholly in T. 66, R. 6, W. It stretches from the southwest quarter of sec 32 to the western boundary of sec. 24, with an average width of a quarter of a mile. The timber has been completely burned on the Minnesota side, but remains flourishing on the Canadian side. Both shores are walled in by massive hills of argillitic and graywackenitic slates intersected by numerous dikes of diabase. These hills attain elevations up to 200 feet and on the north shore present in places lofty vertical precipices, especially at the eastern extremity. Oak lake, so named from a few small oak trees at the eastern extremity, is about half a mile in length and lies wholly in sec. 24, T. 66–6. The soil-covered and arable areas near the shores of these lakes are very limited in extent, and in the absence of timber the region presents few inducements to settlement.

N. E. ¼, sec. 30, T. 66-6, (as of Minn.). North shore Ottertrack lake. Graywacke—a grand cliff fifty feet perpendicular, with a talus slope of thirty feet.

Rock 553. Fine textured graywacke.

N. E. ¼, N. E. ¼, sec. 32, T. 66–6, (as of Minn.). A mass of diabase (554).

Same sixteenth as the last. Graywacke again (555), but with a slightly slaty aspect.

S. W. ¼, S. W. ¼, sec. 28, (as of Minnesota). Canadian shore.

Rock with the aspect of graywacke, but when broken, feldspar crystals and grains are seen emerging from a feldspathic, chloritic groundmass, and glassy crystals of quartz are scattered here and there.

Rock 556. Chlorite gneiss, Ottertrack lake.

N. W. ¼, sec. 33, T. 66–6, Minnesota. Graywacke with clear small grains of glassy quartz disseminated.

Rock 557. Graywacke, Ottertrack lake.

S. E. ¼, sec. 28, T. 66–6, Minnesota. Tough, slaty argillyte (558), in places graywackenitic.

Near centre sec. 27, T. 66–7. Lofty cliff of dark, fine graywacke—rock 559.

N. E. ¼, sec. 27, T. 66–6. A presq'ile formed by a hill about 100 feet high. The rock is still graywacke.

S. W. ¼, sec. 23, as of Minnesota. Graywacke (560), with heavy beds dipping N. about 40°; but these do not appear sedimentary, and I do not find indications of sedimentary structure over any part of the cliff.

Much of the rock in this vicinity is massive slaty, and the hills rise 125 to 150 feet above the lake.

S. E. ¼ sec. 23, T. 66-6. Siliceous argillyte (561). These exposures are so lichen-covered that bedding features are concealed. Opposite this point is an imposing precipice 150 feet high.

N. W. ¼, sec. 24, T. 66-6, as of Minnesota. Siliceous argillyte like last, but sedimentary bedding is distinct (562), standing vertical and much warped.

On portage from Ottertrack to Oak lake. A ridge formed of rock with weathered surfaces strewn with white grains which prove to be crystals and fragments of feldspar, and some grains of flinty quartz. The groundmass is graywackenitic, with traces of slaty structure.

Rock 563. Porphyroid graywacke.

The portage is a third of a mile long and rough, ending in a swamp.

N. E. ¼, sec. 24, T. 66-6. Oak lake. Graywacke, fine and gray.

N. E. ¼, sec. 24, T. 66-6. East end of Oak lake.

Compact mass of grains of feldspar and glassy quartz in an imperfect groundmass of feldspathic character. In places a vertical bedding is visible.

Rock 564. Compact granulyte.

The route from Ottertrack to Saganaga lakes illustrates well a passage from argillyte and graywacke to gniess and syenite. We pass no transition from distinctly bedded to distinctly massive rocks. The bedding becomes obscure in the graywacke and the rock soon reveals itself as a groundmass in which emerge into view first obscurely and then distinctly, crystals and crystal fragments of feldspar. The rock is porphyritic, but the bedded structure is so evident that I distinguish it as porphyrel. Almost simultaneously individuals of quartz rise into view and we have a quartzitic porphyrel, or, with little groundmass, a granulyte. A little further on in this series of changes a chloritic constituent becomes apparent; and still further this is seen to be but an altered hornblende, and the quartzitic porphyrel has become a real syenitic gneiss. The bedding of the gneiss is demonstrably the prolongation of the porphyrel, the graywacke and the argillyte.

§ 8. LAKE SAGANAGA.

Lake Saganaga is in many ways interesting. It carries the boundary of the state farther north than at any other point east of the thirteenth range west—the boundary passing through the southern part of T. 67-4. The lake itself reaches into T. 68-4—if we extend into Canadian territory the United States system of geographical descriptions. With this understanding we may say the body of the lake stretches from the middle of T. 66 into the southern tier of sections of T. 68. But there are three southward stretching Arms of which the small westerly Arm reaches sec. 24, T. 66-6, the long middle Arm reaches Red Rock lake in sec 28, T. 66-5, and the easterly Arm reaches sec. 31, T. 66-4. In dimension from east to west this lake extends from sec. 24, T. 66-6 into sec. 23, T. 67-4, as nearly as I could estimate. This makes the extreme length of the lake from north to south of about twelve miles, and an extreme breadth from east to west of about eleven miles.

It must be explained, however, that locations extending into Canadian territory can only be regarded as rough estimates. As the Canadian territory has not been surveyed and platted, as far I am informed, the distances and configurations of the Canadian shores were laid down from the canoe by estimation while coasting along A good pocket compass was always in hand, and bearings were taken of salient points from each other. Such methods are of course, undesirable; but it seemed important to obtain as good a map as possible of certain parts of the lake.

Another interesting feature of this lake is its labyrinth of granitic islands and the intricacies of its deep winding bays and channels. A rough measurement of the shore-lines bordering Minnesota gives 48 miles. A similar measurement of Canadian shores traversed and platted gives 33 miles. Through T. 67-5 and 66-5, the Canadian shore not meandered, would amount to perhaps 15 miles. This would give a total shore line of nearly 100 miles, without reaching the island shores.

The country bordering the shores presents a succession of rounded hills rising to hights of 100 to 200 and 300 feet. The timber on the Minnesota side is mostly burned. What remains consists of spruce and Jack pines, with patches of poplar and white birch. Tamarack is also found in the swamps. The features of the country are carved out on a broad, bold scale The landscape is striking and abundant in scenic interest; but it is dreary and inhospitable.

The lake rests mainly in the indentatations and undulations of a syenitic surface. The Minnesota shores are all syenitic, except the most southern prolongations of the great central and eastern Arms, which attain the region of schists bordering the great syenitic mass. On the southwest is found a noteworthy conglomerate; and on a Canadian island near the eastern shore, a similar conglomerate. My exploration shows that most of the north shore borders on an area of earthy schists apparently of the same age and nature as those near Vermilion lake. The indications point to a continuation of these schists along the northwest shore, through Towns 67–5 and 66–5. Professor Irving reports schists also on the eastern side; but though I saw most of the eastern side I did not observe them.

The course of the observations through lake Saganaga begins at the southwestern extremity on the boundary, and proceeds eastward along the windings of the three southward bays to the portages or rapids into the adjacent lakes—Red Rock and Sea Gull, including Sea Gull river (so-called) and continues to the rapids out of Granite lake. From here, the whole Canadian shore is meandered through T. 67–4 (as of Minnesota) into T. 68–4, as I estimate, aud thence about as far as sec. 10, T. 67–5 (as of Minnesota). The Canadian shore from here to the place of beginning was not visited.

The most intricate and interesting portion of the body of the lake is mapped on the following page, and the halt numbers within that limit are expressed on the map.

The formation at the entrance of Saganaga lake is similar to that near Oak lake, but here it weathers red. It is essentially a compact granulyte (565).

S. E. ¼, sec. 24, T. 66–6. In the small southward Arm.

Here the formation is mostly argillyte, striking in the unusual direction of N. 34° W., standing vertical, and alternating with beds of graywacke, very fine, sometimes aphanitic, and everywhere feldspathic. This is evidently a prolongation of the rock on Oak lake at sec. 24, 66–6.

Rock 566. Argillyte, quite characteristic.

Rock 567. Graywacke, interstratified with 566.

S. E. ¼, sec. 24. Extremity of bay. Porphyroid graywacke (568) like No. 563, on Oak lake.

Along the shore southeast of this bay, the rocks are very distinctly slaty, standing nearly vertical.

N. E. ¼, sec. 24, T. 66–6, on town line. Blueberry island. This is a quarter of a mile east of the termination of the portage. The granulyte of Oak lake (Nos. 564 and 565) assumes a very quartzose condition (569)—the grains of quartz at least two-thirds of the whole mass.

It will be interesting to note that from the region as far as the

Saganaga syenite is traced, large grains of quartz constitute a distinctive character.

N. W. ¼, S. W. ¼, sec. 19, T. 66-5. Chlorite syenite (570). The grains of quartz are large, angular and numerous, and on weathered surfaces stand out prominently. The feldspar exists in sub-angular patches, imbedded with the quartz in a groundmass which is mostly chloritic, and in places develops chlorite spots, while in other places, hornblende forms emerge into visibility. So, apparently, a syenite either appears or disappears. These characters I have learned to recognize as the borderland between schistic and gneissic areas.

Centre of sec. 19, T. 66-5. Chlorite syenite like the last. This rock here differs from the chlorite gneiss of Pipestone rapids, in having the quartz gathered in crystalline aggregates.

S. W. ¼, S. E. ¼, sec. 18, T. 66-5. Chlorite syenite, but with quartz crystals still larger (571). Here also are associated hornblende appearances.

S. E. ¼, S. E. ¼, sec. 18, T. 66-5. Chlorite syenite, with quartz weathering very conspicuous.

N. E. ¼, S. E. ¼, sec. 18, T. 66-5 Here the rock presents a fairly well developed hornblende (572). The isolated individuals of quartz are about one-third of the mass; and there are two varieties of feldspar—a pale, lemon-colored and a more abundant pinkish—the latter not well isolated.

Centre of sec. 17, T. 66-5. Syenite like last.

For the space of a mile along the direct coast from here no outcrops are observed.

N. W. ¼, S. E. ¼, sec. 9, T. 66-5. Syenite, the individual minerals all handsomely isolated—the quartz grains glassy and much the largest. Rock 573.

Great Middle Arm, Saganaga lake.

Centre of sec. 10, T. 66-5. This position faces the greatest body of the water. Here is an expanse of water looking northeastward, estimated at six miles in breadth. This is at the mouth of the great middle Arm of the lake, which from here has a general direction southward and southwestward. The formation is syenite, mostly porphyritically quartzose as before; but I find some portions with all the constituents fine.

Rock 574. Fine grained syenite as above.

S. E. ¼, N. E ¼, sec. 15, T. 66-5. Syenite, still porphyritically quartzose. Blotches two or three inches in diameter have undergone a ferruginization.

This point is over a mile from 1177, the centre of sec. 10, 66–5, but several examinations of the rocks have been made, to find a continuous shore-line of syenite. Near this locality the sound of a cascade is heard in the stream coming in from the small lake in secs. 20 and 21.

S. W. ¼, S. E ¼, sec. 15, T. 66–5. Syenite with large angular grains of quartz.

S. W. ¼. N E. ¼, sec. 22, T. 66–5. Syenite exactly as heretofore.

Centre S. W. ¼, sec. 22, T. 66–5. Syenite as before. It does not present a red appearance along the shores because lichen-covered.

Rock 575. Saganaga syenite.

N. E. ¼, N. E. ¼, sec. 28, T. 66–5. Syenite as before.

This Arm is indented by constantly occurring deep and sinuous bays and is studded with low syenite islands.

S. E. ¼, N. W. ¼, sec. 14, T. 66-5. Island near mouth of middle Arm. A singular rock in an unexpected situation. From the water, on the east side of the island, white quartz is seen in considerable abundance. On examination I find some veins one or two inches in diameter; but most of the quartz results from the excessive abundance of the usual quartz grains. These are very unevenly disseminated—sometimes aggregated, and in places, nearly wanting. The rock itself is not, of course, a characteristic syenite. All hornblende has disappeared. A feldspathic matrix remains, with some green specks and spots, and the quartz is imbedded in it. Some of the broken surfaces of the rock have a sericitic lustre. The formation, on the whole, appears roughly bedded, with a dip of 63° toward S. 70° W. But this dip is not persistent. In places, the rough beds stand on edge —yet even here I suspect these are jointed prisms, since the southwest bedding can still, in some cases, be detected. The edges of the outcropping layers are a mass of small, lenticular parts packed closely together, and weathering exceedingly rough. This sort of rock extends along the east side of the island for eight or ten rods.

Rock 835. Quartz from island as above.

Rock 836. Samples of the formation.

Rock 837. Samples eight rods further north.

North end of the island. I considered it necessary to trace this peculiar formation further. At the north end of the island, the appearance is similar. The surface has a peculiarly brecciated aspect.

Rock 838. Sample from north end of the island.

Rock 839. Sample showing the weathered surface.

Rock 840. A rounded mass included in the rock.

By degrees, in approaching the northwest angle of the island, we find a condition of the rock (841) in which the feldspar weathers reddish.

To some extent now the formation is a granulyte. There is no other exposure on this island.

Little island one quarter mile southwest of last. The rock is ordinary syenite.

Point of main land east side. N. W. ¼, S. E. ¼, sec. 14, T. 66-5.

Looks like ordinary syenite of the region. The quartz grains are rather large. The principal feldspar is reddish, and there is also a little whitish. The dark mineral is a dark greenish viridite with light green streak.

Rock 842. Viriditic syenite.

S. W. ¼, S. W. ¼, sec. 31, T. 66-4. North end of portage from Seagull to Saganaga lake. Syenite, unlike that at the south end of the portage. (See Seagull lake, rock 608). It contains small hornblende individuals.

S. W. ¼, sec. 30, T. 66-4. Island in so-called Seagull river.

The syenite here contains a predominance of small quartz grains, and somewhat sparsely scattered kernels of very large size—up to five-sixteenths, and rarely, half an inch in diameter.

N. W. ¼, sec. 19, T. 66-4. Saganaga syenite—609.

This so-called river is little other than a long irregular narrow bay setting southward from Saganaga lake. Still, it is somewhat more than that since a gentle flow of water sets southward and at the narrows a quarter of a mile further south, we find gentle rapids. The shores are very continuously hemmed in by rounded hills of Saganaga syenite.

S. W. ¼, N. W. ¼, sec. 17. T. 66-4. At the termination of so-called Seagull river. The last narrows half a mile south of here are set down as "Caribou narrows." Saganaga syenite (610) continues, but here with an increase of hornblende. The red feldspar is well isolated.

Near centre of sec. 8, T. 66-4 Syenite without coarse quartz, though the prevailing character along this shore is otherwise. This formation contains rounded pebbles of another variety of syenite composed mostly of hornblende (perhaps augite) and small disseminated quartz grains and little feldspar.

Rock 611. Syenite with pebbles.

Body of the lake (Saganaga).

S. E. ¼. sec. 5, T. 66-4. Saganaga syenite (coarse quartz) and also containing rounded pebbles of dark hornblende syenite as before.

Rock 612. Syenite with pebbles, as above.

N. E. ¼, sec. 4, T. 66-4. Island. Saganaga syenite, still with dark rounded pebbles.

In reference to the occurrence of water-worn pebbles in the syenite, compare especially Rocks 599-607 in Seagull lake, and Rocks 615-624 in Saganaga lake.

Syenite hills rise on every hand in all this region. The island in T. 67-4, Minnesota, consists of low syenite protuberances mostly not over 30 to 50 feet high, but others reach 150 feet.

Rapids out of Granite lake, Saganaga syenite (613). The quartz kernels are up to half an inch and more in diameter.

The rapids *seem* to be incorrectly located on the plat. They come in at the south extremity of the little bay, and *not* on the east of the bay. They form a pleasing view, and I took a successful negative of the scene.

Determined to make an examination of the Canadian shore, I sketched in as well as I could the configuration of the land on the same scale as the American township plats.

NOTE.—The localities at which rock samples were collected, indicated on the map of Saganaga lake by the original "halt" numbers, correspond to the rock numbers as follows:

1218	is the locality for rock	613.	1231	is the locality for rock	633.
1219	"	614.	1234	"	634-638.
1220	"	615-624.	1235	"	639.
1222	"	625-626.	1239	"	640.
1224	"	627.	1240	"	641.
1225	"	628.	1241	"	642.
1226	"	629.	1242	"	643-4.
1228	"	630-632.			

[N. H. W.]

Near centre of sec. 34, T. 67-4, (as of Minn.). A little island which from the surprising character of its geology I named ***Wonder Island.*** It is northwest of a smaller island, and northeast of an island rock.

Saganaga syenite. Rock 614. Kernels of quartz up to half an inch in diameter. Hornblende greenish-black, well isolated. Feldspar reddish and abundant. The formation contains occasional

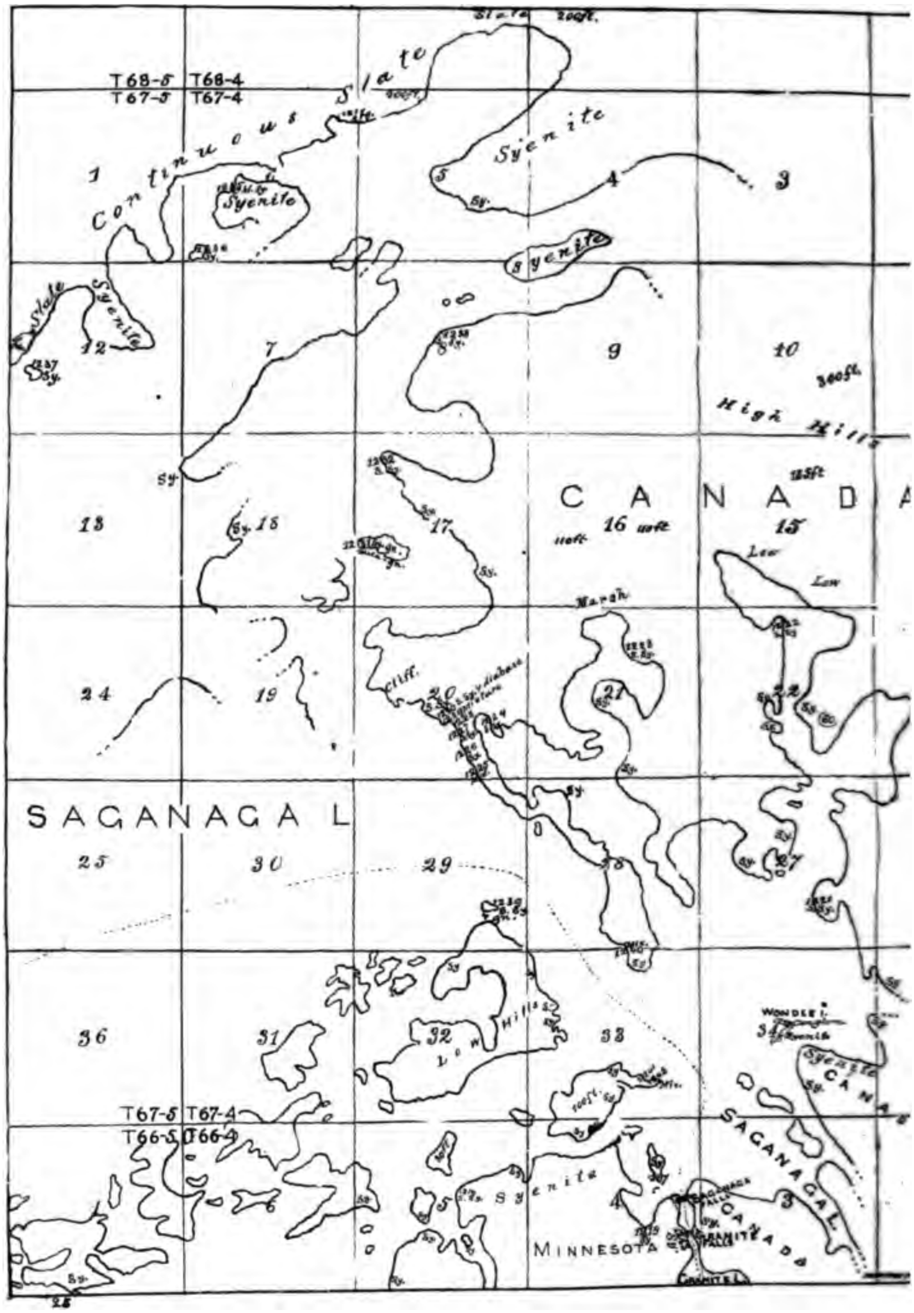

Fig. 25.—*Map of the principal portion of Saganaga lake.*

dark rounded pebbles, as before. This is at the south end of the island.

North end of Wonder I. near centre of sec. 34, T. 67-4, (as of Minn.). Here is a real conglomerate. Well rounded pebbles are crowded together as in the Ogishke conglomerate, and the general appearance is entirely like that of the Ogishke. But there is an important difference. The groundmass of the Ogishke is fragmental, though often highly altered. That of this conglomerate is regular syenite. A real conglomerate of rounded pebbles imbedded in a groundmass of typical syenite is certainly an extraordinary occurrence. I have never seen it before. I have never read of it. But if the thing is a fact,probably this is not the only place where it has been observed.

I copy here the suggestions made to my mind, and written down on the spot:—The inferences from the occurrence are important. A puddingstone like this is universally regarded as of fragmental origin. Not only that, but of origin through aqueous agency. The conglomerates associated with eruptive sheets on Keweenaw Point, once suggested to be of igneous production, are now regarded as due to aqueous agency. So, if this conglomerate is sedimentary in nature, the syenite groundmass must, at the time of the deposition of the pebbles, have been also, in a state of semi-fluidity under the influence of water. It may have been subjected simultaneously to energetic thermal action; but it was not in that state of fluidity which accompanies, and results from, recent eruption as molten matter from some deep source. This view of the origin of granitic rocks, I have heretofore maintained; and this remarkable observation is a gratifying confirmation of the correctness of the opinion.

The conglomerate is seen on the shore in two patches separated by a few feet of syenite, and with syenite on the other two sides. These patches emerge from beneath the water, and in the space of six feet, pass under the soil of the island. In one case, the conglomerate presents a thin edge landward, overlying syenite, as if it had been a sheet dipping northward at a low angle. But I do not consider this incident important; since I imagine that beds of pebbles may have been placed in any position whatever, in the progress of these movements which brought water-worn pebbles and real syenite in such extraordinary juxtaposition.

The following is a general plan of the phenomenon:

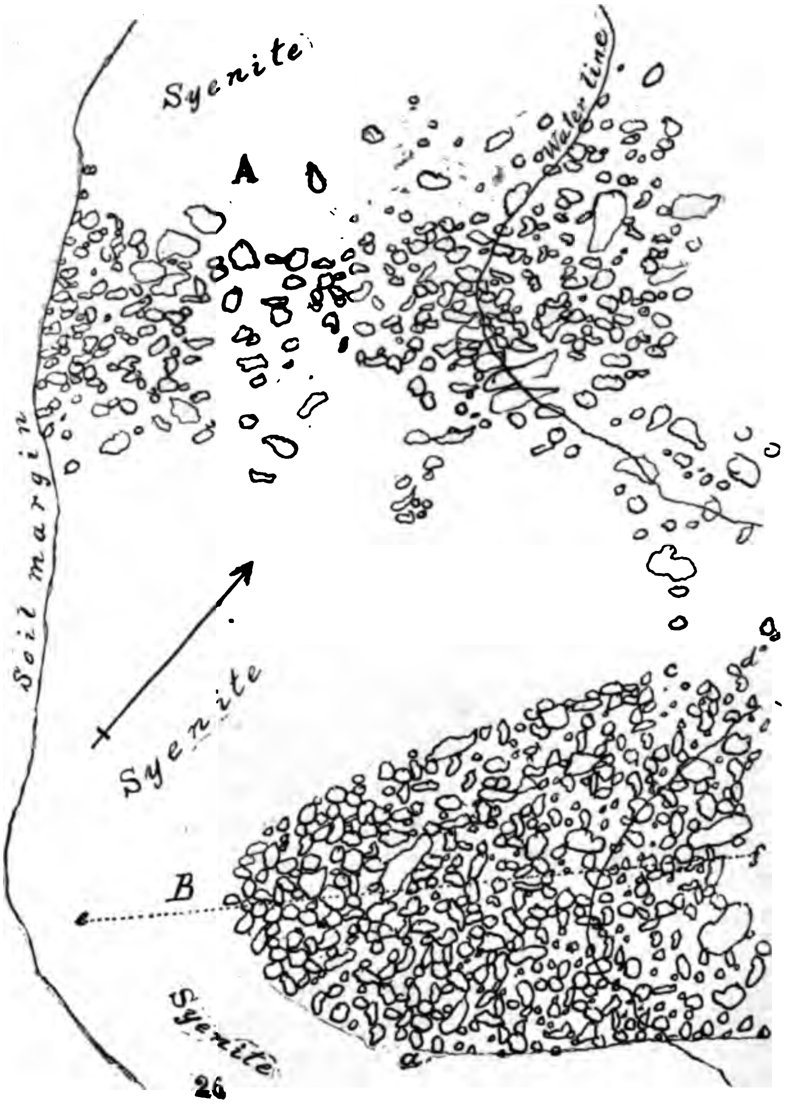

Fig. 26.—*Relations of conglomerate and syenite at Wonder island, east shore of lake Saganaga.*

Here are two patches of conglomerate, A and B. The first is about four feet wide, and the other, three feet. The separating syenite is ten feet—here shown reduced. The patch A graduates into the syenite on both sides; B is sharply limited, especially along the line *a b*, where a distinct joint appears between it and the syenite. From *c* to *d* this patch may be seen overlying the syenite, for the thin edge is broken away. Around the remainder of the border of B, the conglomerate appears to terminate with a thin edge, but it is so closely united with the syenite that it is difficult to say whether clean syenite underlies, as along *c d* or not. The appearance of B is as if a vertical section along *e f* would present the relations following:

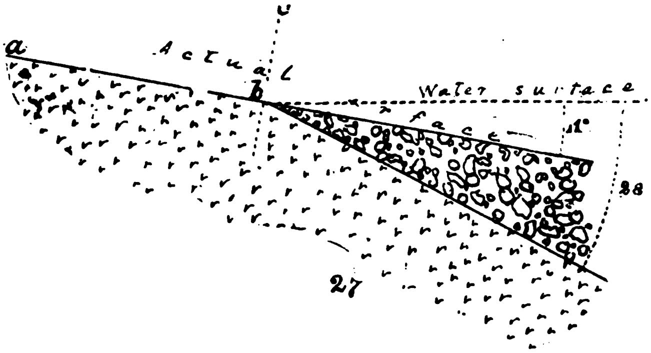

Fig. 27.—*Theoretical vertical section of the conglomerate, fig.* 26 *along the line e f in the mass B.*

These appearances may, however, be illusory. The lower limit of the conglomerate may not be as abrupt generally as it appears when the thin edge is broken away. Still, if it graduated downward into the syenite, some pebbles should exist to the landward of the termination at *b*, that is along the interval *a b*. But they do not exist. However, as before said, I base no important inferences on this appearance.

A single pebble *g*, appears beyond the joint *a b*, which separates the principal mass of conglomerate from thc syenite.

As the diagram shows, the pebbles are more closely arranged in the patch B, than in A. It might at first be supposed that B was a bed of pebbles over which the syenite had been poured in a liquid state. But certainly, the other patch could not be so conceived. Here the pebbles are not supported by each other Evidently, they have been deposited in a paste dense enough to prevent their falling together. The epoch of the paste and that of the deposition were the same. The conglomerate and the syenite were put in place simultaneously. The syenite was not "erupted" after the conglomerate existed. The conglomerate was not laid down on the solidified syenite. I have seen on an island in Gabimichigama lake, a pile of angular fragments of "muscovado," over which gabbro had been poured in a state fluid enough to permit it to fill all the interstices among the fragments o muscovado. (Report 1886, p. 172,) But the pile of fragments wa self-supporting. It was like a talus at the foot of a cliff over whic water had been poured, and had congealed in all the cavities. Th case is entirely different. Even though the mass B is more compa than A, it will be seen that it, even, could not have been originally self-supporting mass of pebbles.

The pebbles are quite uniform in lithological aspect. They are u formly dark colored, and in a rough way, would be called greenston I have endeavored, however, to make some field discriminations, wi the following result:

Rock 615. Lamellar augite, in coarse agglomerations.
Rock 616. Lamellar augite in fine agglomerations, with a min quantity of light feldspar disseminated in strings and grains.
Rock 617. Lamellar augite with conspicuous grains of feldspar.
Rock 618. Augite, feldspar and epidote.
Rock 619. A lamellar mineral, soft as talc or chlorite.
Rock 620. Pale green augite inclosing lamellar augite.
Rock 621. Augite hyposyenite.
Rock 622. Greenish, transparent augite in slender prisms.
Rock 623. Lamellar augite like 615, but of a pale green color.
Rock 624. Saganaga syenite inclosing above pebbles.

A majority of the pebbles are like 615, 616 and 617. There is syenite, no quartzyte, no jasper, no sedimentary fragment. In one stance, I saw two or three large grains of quartz imbedded in a la pebble of 617.

This differs, therefore, from the Ogishke conglomerate both in mineral character of the pebbles and the nature of the groudmass.

This is the only locality at which I have observed pebbles of t nature or any other, in such abundance in a matrix of syenite. Sc tered pebbles seen heretofore in the syenite of this lake, but m especially in that of Seagull lake (as will be shown) are of a sim nature to these, and in my opinion have had a similar origin and s ilar history. However, in the E. ½ of sec. 7, T. 65-5, near the nor western shore of Seagull lake a conglomerate has been reported to by Mr. Frank Stacy as the Ogishke conglomerate; but it seems m probably of the nature of the conglomerate on Wonder island. T region referred to by Mr. Stacy is within the limits of the mas Saganaga syenite.

I visited sundry other islands in the vicinity of Wonder island. I found no more conglomerate. Single black pebbles, however, are of frequent occurrence.

Proceeded to follow up the east shore of Saganagà lake, but after paddling two or three miles found ourselves at the head of a deep narrow bay. Returning from this we entered another deep sinuous bay reaching nearly as far north. From the head of this we returned nearly to Wonder island, and at length struck into a channel which proved to be the main passage to the north shore.

Sec. 27, T. 67-4, as of Minnesota. Main land east side. Saganaga syenite. The syenite is continuous along this shore.

Northern part of sec. 22, T. 67-4, as of Minn. Saganaga syenite (625). A few pebbles. A dyke of another syenite (626) three feet wide, striking N. 40°W. and dipping N. 80°, contains much hornblende and little quartz.

The formation contains numerous rather angular pieces of dark rock which proves to be simply another syenite similar to that of the dike. The subject could not be investigated on the spot sufficiently to determine whether they are wholly identical with the dike-syenite. Their identification would create a problem of some difficulty, and the presumption is that the two syenites are not identical.

Sec. 21, T. 67-4, as of Minn.; near head of second winding bay. Saganaga syenite unchanged.

Sec. 20, T. 67-4, as of Minn. Saganaga syenite (627). The feldspar is mostly light colored. Contains some pebbles of diabase.

South part of sec. 20, T. 67-4, as of Minn. Rock very unhomogeneous. The greater part is a dark chlorite-hornblende, mostly with small grains of red feldspar disseminated through it (628) Much however, consists of red feldspar disposed in irregular strings, bands and vein-like forms A good deal of epidote also, is gathered in the fissures. The rock presents a very ragged exterior, and easily chips to pieces.

A few rods further north. A ragged-weathering syenite, entirely different from the Saganaga variety. Composed largely of brilliant black hornblende with some feldspar disseminated through it, and occasional grains of quartz.

Rock 629. Black syenite.

Sec. 20, T. 67-4, as of Minn., Saganaga syenite. Near the last Saganaga syenite, with dikes and irregular prolongations of diabase (630), having shining, slender rods of hornblende and a little feldspar. This syenite weathers very rough.

Rock 631. Thin lamellar augite resembling the pebbles 615.

Rock 632. Red feldspar and chloritic hornblende, like 628. Near the last, centre of sec. 20, T. 67-4, as of Minn. This is a mixture similar to that of rock 628.

Centre of sec. 20, T. 67-4, as of Minn. Saganaga syenite and diabase, like rocks 630-32.

S. W. ¼, sec. 17, T. 67-4, as of Minnesota. Island. Mostly Saganaga syenite; but some of the formation is a micaceous gneiss (633), with minerals arranged in parallel beds. First mica seen on this lake.

Sec. 17, T. 67-4, as of Minn. Point of cape. Saganaga syenite. Breaks into huge cuboidal fragments.

Sec. 8. T. 67-4, as of Minn. Saganaga syenite.

Main-land of extreme north shore. Supposed near the northern line of T. 67-4. To the east of this a broad bay extends half a mile farther north. Here is a hill attaining an elevation of about two hundred feet. A range somewhat continuous extends east and west for four or five miles, having an aspect different from that of the isolated domes of the syenite, and differing also, in its dark color when seen from a distance. At this point it is a dark, semi-slaty rock. Climbing to the summit which is here about 200 hundred feet above the lake, the slatiness is in places quite marked, though tending to split in coarse fibrous forms, and not altogether in laminæ or sheets. It has marked cleavage in planes mostly S. S. W. at an angle of 75°. and hence approximately at right angles with the bedding, the dip of which is N. N. E It is intersected by veins of quartz.

Rock 634. Showing the slatiness.

Rock 635. More solid portions.

Rock 636. Showing the cleavage.

Rock 637. Showing warped, parallel lamination.

Rock 638. Quartz from a vein.

From this summit I see a range of hills about fifteen miles distant, following the horizon from a point S. 30° W. to a point S 10° E.—and less elevated, to a point S. 30° E. This is probably the "Giant's Range" showing the culmination of the syenitic mass separating the Kewatin slates of the north from the Kewatin and Animike slates of Gunflint lake.

An island in about sec. 6, T. 67–4, lying less than a quarter of a mile from the north main shore. This island is mostly syenite; but here, near the western end it is syenite mixed with chlorite syenite (639).

Another but smaller island southwest of the last judged to be within the same sec. 6, and lying but an eighth of a mile from the slaty main land. This is ordinary syenite.

A little further southwest a promontory half a mile long projects into the lake, and the main mass of this is syenite. But the main land continues slaty.

A small island supposed to lie in the western part of sec. 12, T. 67-5, as of Minnesota. This is good Saganaga syenite, with rude horizontal bedding, like some of the syenite seen on Basswood lake and elsewhere. (Compare Halts 440, 443, p. 99, Report, 1886.)

Supposed to be in sec. 11, T. 67-5, as of Minnesota. About a mile farther southwest. Slate continues, having about the same characters and same dip as described at the north extremity of the lake. It is intersected here by a dike of diabase and a vein of quartz.

There is good reason to believe that the same argillitic slate continues along the west shore of Saganaga lake as far as the national boundary where my observations began. The north and northwest shores mark the division line between the syenite on the south and the earthy schists on the north. I did not discover the existence of the usually intervening crystalline schists, but as the belt of these is in other parts of the region somewhat narrow, it cannot be affirmed that the earthy schists occur in immediate contact with the syenite. The chlorite syenite and chlorite gneiss seen at several points hold the usual intervening position. The micaceous gneiss seen on the island in sec. 17, lies very probably in the vicinity of mica—or hornblende schist. It is just as likely, however, to be a detached mass, since the ordinary Saganaga syenite lies between it and the north shore slates.

Thinking the north shore had been examined as far as my time would permit, I determined to strike directly across Saganaga lake for Saganaga falls, out of Granite lake. In passing among the labyrinth of islands in the southern part of the lake, I found to my annoyance several erroneous records of the land surveyors. For instance the blazes on the trees between secs. 31 and 32 read 32 and 33 in several places. But the meander corners between secs. 29 and 32 set things right. It is worthy of note that after traveling so sinuous a course from Wonder Island, without sight of a known landmark, with distances all estimated by the eye, and directions determined by a good pocket compass, the course ended at a point but little more than a mile distant from the calculated position.

Island 20 rods north of most northerly angle of Big island platted on

T. 67-4, Minn. Saganaga syenite and biotite gneiss (640)—the former prevailing.

Land on east of north side of Big island. Sec. 33, T. 67-4. The formation is mostly syenite, as on the contiguous island; but for the space of a quarter of a mile occurs the formation which I have recorded as "mixed." It is mostly a chlorite-augitic groundmass with a small quantity of light feldspar and a greenish mineral disseminated; in many places minute specks of a red feldspar, and some veins of this. Rock tough, seamed, not hard.

Rock 641. Chlorite-augitic rock.

East extremity of island southeast of Big island. Sec. 33, T. 67-4. Very ragged-weathering formation, consisting mostly of lamellar augite like 615, with grains of red feldspar sparsely disseminated, and numerous nodules from an inch to three inches in diameter of syenite composed of white feldspar, transparent granules of quartz and jet black crystals of hornblende. This, apparently, *is the rock which has yielded pebbles to the prevailing syenite*

Rock 642. Mostly lamellar augite in coarse agglomerations.

Near extreme point of same island, a few rods east of the last. A dike of white weathering feldspar with disseminated grains of quartz. Three feet wide, vertical. The feldspar is livid pinkish, not striated. This intersects a formation substantially like that described in connection with rock 642, but the disseminated red feldspar is in coarser grains.

Rock 643. Feldspar and quartz from dike.

Rock 644. Formation containing the dike 643.

Farther along and at the extreme point, the syenite is seen alternating and mixed with, the augitic rock.

§ 9.—GRANITE LAKE.

Granite lake, so-called, undoubtedly from the high conspicuous and rugged hills which environ it, lies in the midst of the Giant's range, and presents a physical aspect even more forbidding than Saganaga. The hills are not lofty, rising only fifty to one hundred feet above the lake; but they are mostly bare, with a massive, sterile expression as if the world had but recently been finished and vegetation had not yet taken root. But they bear nevertheless the evidences of vast denudation and reflection presents them to us as relics of a remote antiquity. The entire township in which the lake rests is a surface of rolling hills and domes with narrow marshes or clear lakelets between. It is distant only about two miles east from the eastern long arm of Saganaga; and Gull lake extends its head to within two miles of the principal bay of Granite lake. This lake lies wholly in township 66 of range 4 west, having a length of little more than six miles. Its average width is about three fourths of a mile, but in places it widens on the Canadian side to about two miles, and south of this, narrows to a simple stream interrupted by numerous rapids which will be described. In the midst of a long series of rapids leading out of Pine lake is a small expansion a third of a mile long which is named Basin lake. These features will be more particularly described.

From Saganaga lake the lower or Saganaga falls are passed by a short portage on the west side.

Portage at the upper, or Granite lake falls, S. E. ¼, sec. 4, T. 66-4. The portage is on the east side of the stream and about 28 rods in length. Parts of it are quite difficult, in consequence of rocky slopes. The landing and embarkation are also difficult. The rock is regular Saganaga syenite.

N. E. ¼, N. E. ¼, sec. 16, T. 66-4. Saganaga syenite, with quartz individuals a quarter of an inch in diameter. The western shore of the lake to here is quite direct and trends south. Syenite presents itself almost uninterruptedly. A few poplars and Jack pines are seen, and, on the low ground at this point, tamaracks and birch.

S. E. ¼, S. E. ¼, sec. 16, T. 66-4. Saganaga syenite continuously.

S. E. ¼, S. E. ¼, sec. 16, T. 66-4. Saganaga syenite in a much shattered bluff. The syenite along the shore weathers pale red.

S. E. ¼, S. E. ¼, sec 21, T. 66-4. Saganaga syenite. Occasional greenstone pebbles. The country becomes diversified with high rounded hills from fifty to one hundred and fifty feet in altitude above the lake.

N. E ¼, N. E. ¼, sec. 28, T. 66-4. Saganaga syenite.

S E. ¼, N. E. ¼, sec. 28, T. 66-4. A massive exposure of Saganaga syenite.

Near centre of sec. 27, T. 66-4. Saganaga syenite; rock 645.

The stream connecting the two portions of Granite lake is a broad, deep river, widening in the middle. By an abrupt bend in the stream the current sets south. The shores are lined with massive syenite containing coarse quartz.

S. E. ¼, S. E. ¼, sec. 22, T. 66-4. Near outlet of southern section of Granite lake. Saganaga syenite.

A fragment of slate lies on the shore which is identical with that north of Saganaga.

The syenite in this region is but very faintly red.

The surveyor's plat becomes again very treacherous. This lobe of Granite lake is represented as having a broad southern portion; and no rapids are laid down until we reach the southern extremity, in the northern part of sec. 36. Now, as a fact, the Canadian shore approaches the American in the southern part of sec. 26, and here are rapids an eighth of a mile long, flowing north. There we navigate. A distinct current flows also through the narrows on the line between secs. 23 and 26. Beyond, or south of, the rapids, we come into a broad stream, with a quite perceptible current, widening to an eighth of a mile; and in the midst of this we discover a meander stake to help us out. We examine one bearing tree and cannot make out whether it is 35 or 36. Very well, the other tree should decide. Alas, the other reads 25 or 26, and no one can tell which—such is the fidelity of the government surveyors. After studying the hieroglyphics of the first tree again and again, I conclude they read 35. Then those on the north tree must stand for 26. But the line between 36 and 25 is platted as passing along rapids—though east and west rapids. The configuration of the shores shows it impossible that we have reached these rapids. There are then long rapids not platted and in a place where the Canadian shore is represented two-thirds of a mile distant. Such facts, while they are not geology are some of the geologist's experiences.

S. W. ¼, S. E. ¼, sec. 26, T. 66–4. Near meander stake. Saganaga syenite.

N. W. ¼, N. E. ¼, sec. 35, T. 66–4. At rapids which also, are not on the plat—which shows Canadian shore half a mile distant. Saganaga syenite. Quartz exceedingly coarse.

These rapids are in two sections, altogether a quarter of a mile. The canoes were pulled up with considerable effort.

Rapids S. E ¼, N. E ¼, sec. 35, T. 66–4. These rapids also are not on the plat and they require to be portaged, though in going down stream, they may be "shot" in an empty canoe. The portage lies south of the rapids and crosses a point of land. It ends on a little lake, which from its form I named Basin lake. The syenite is the regular Saganaga variety which prevails throughout this region. The syenite generally about here, weathers white.

Basin lake is half a mile long and a quarter of a mile broad lying in the N. W. ¼, sec. 36, T. 66–4. At the end of this are other rapids not on the plat. These appear to be the lower of a series of four rapids—the others platted—which occur in a northward bow of the stream. We manage to flank all these. From a little bay at the southeast corner of Basin lake we pursue an indistinct trail southeastward and along a difficult route, shunting a big syenite hill on the right, and in about a quarter of a mile, reach a little lily-bearing bay opening southeastwardly into a small lake in the southeast part of sec. 36, which proves to be the northern extremity of Pine lake. So we escape four portages, but lose fully a mile of coast line.

§ 10.—PINE LAKE.

Pine lake lies in the southeastern part of T. 66-4, W. and the northeastern part of T. 65-4, W. Its length is about two and a half miles, with an average width of a third of a mile, with narrows and rapids at about mid-length. Its entire shores are bound by massive syenite not greatly elevated above lake level. The vegetation possesses no importance.

N. E. ¼, S. W. ¼, sec. 36, T. 66-4. Twin-Bay portage from Pine lake to Granite. High cliffs of the Saganaga syenite (646). Most of the feldspar is white, but some is pale pink. Generally, it is not well isolated. There are greenstone pebbles in the syenite.

The high hill south of this portage and crowding upon it was ascended, on a second visit. I found the usual east-west structure. The quartz individuals, however, were not generally elongated.

N. W. ¼, N. E. ¼, sec. 1, T. 65-4. Near foot of narrows and rapids of Pine lake. The Saganaga syenite has here a jointage structure running east and west, and it seems to be dependent on a system of foliation. This jointage, then, is conformable with the prevailing bedding system of the schists of the country.

N. W. ¼, N. E. ¼, sec. 1, T. 65-4. Near the rapids, on the upper or southerly side. Saganaga syenite (647)—the quartz coarse and conspicuous—the feldspar a groundmass.

These rapids are not on the plat, and it is difficult to ford them.

About half a mile from the southwestern extremity of Pine lake, the sound of a roaring rapid is heard; and here the Boundary river comes in from the east. The portage out of Pine lake is about an eighth of mile south of the stream, and leads in the space of a third of a mile to the southern extremity of a bend in the river.

§ 11.—BOUNDARY RIVER.

The entire chain of small lakes and connecting streams lying along the international boundary may be viewed as simply a stream serving for drainage of the region; but on the nearly horizontal general surface expanding at frequent intervals, to fill the basin-shaped depressions which dot the surface of the crystalline and schistic rocks. There are two of these rivers. One flows eastward and southeastward into lake Superior; and the other flows westward and northwestward into Rainy lake. The dividing ridge between the headwaters of these two streams lies between North and South lakes at an elevation of 1,097 feet above lake Superior, as barometrically determined by Prof. N. H. Winchell.* It is the westerly stream which I have designated the Boundary river. The other is the Pigeon river. The international boundary does not in all cases correspond with the position of these rivers. It follows, in accordance with treaty, the usually traveled canoe route, and this makes several short cuts.

The length of the Boundary river from Gunflint lake to Pine lake, is less than three miles by its windings, and in a straight line it is not over two; but its course is zigzag and the stream is interrupted by half a dozen rapids. It flows through the most desolate and rugged portion of the Giant's Range. Bald syenitic summits rise fifty to one hundred feet above the stream, and in many regions the surface is studded with the blackened erect trunks of the recently burned Jack pine forest. Frost has broken down the ancient precipices, and the ruin of the mountains contributes its weird effect to the impression made by the ruin of the forest.

N. E. ¼, N. W. ¼, sec. 12. T. 65-4. Disappearance of Boundary river. This point is shown in figure 28.

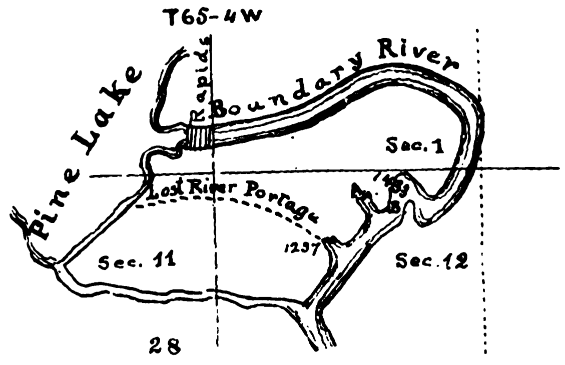

Fig. 28.—*Map of Boundary River showing point of Disappearance.*

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* Ninth Annual Report, Minn. Sur. p. 81.

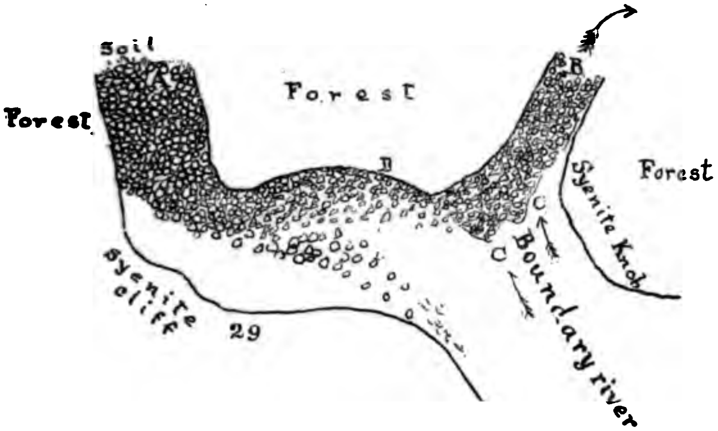

Fig. 29.—*Bowlder-filled ancient channel of Boundary river.*

At the place indicated a singular accumulation of bowlders is seen L. fig. 29) rising apparently in a cobble stone wall to a hight of about fteen feet above the water.

This is the appearance as seen in perspective at the distance of about welve rods toward the south. On approaching nearer the surface exposed to view is seen to be not a wall but a slope of about 20°, and the urious effect is discovered to be simply that of a mass of bowlders filling what is probably an ancient bed of the stream. The bowlders are uite uniformly about ten inches in diameter. The right and left borders of the bowlder-filled bed are abruptly limited by vegetable growths, nd a well developed forest surrounds. The farther limit is also sharply etermined by a fringe of sedges and a forest covering, as shown in gure 29. Standing water approaches the foot of this slope, but no urrent whatever sets toward this old channel.

On the contrary, a channel, B., filled with bowlders through which ie stream actually flows goes out toward the northeast. The water ere entirely disappears. I obtained good photographs of both channels.

I imagine that this is the place of the old preglacial channel, and that rough the agency which transported the bowlders, it became filled. imagine that for ages, the spaces between the bowlders remained fficiently open for the water to flow through. By degrees, however, cumulating *debris* choked the spaces, and a soil formed at the top, ich became overgrown with the forest. The mass of bowlders now en is what remains uncovered by the soil. Vegetation has encroach- upon it from the sides, as fast as the soil could find resting place.

Hence the sharp lateral limits of the bowlder-filled space, as indicated at the surface. On each side where the forest stood before the burning, the bowlders are seen to be exceedingly numerous wherever the soil is removed; and hence I infer that the ancient channel was broader than the space now remaining uncovered by a soil.

The channel B must have been filled in a similar way; and this also must have been preglacial. Supposing the two channels contemporaneous, it was an island which lay between them. The existence of alternate channels rendered it easier for the first to become choked; since, as soon as a hindrance was experienced by the water passing through it, the other may have remained available for the passage of an enlarged flow.

It appears inevitable, however, that the second channel should in time become choked; and then, as no alternative channel remains, the stream will flow over the surface of the bowlders in channel B. In fact, the absence of soil over that surface indicates that already, at times of flood, a portion of the water is carried off by a surface flow.

N. W. ¼, N. W. ¼ sec. 12, T. 65-4. East end of portage from Pine lake. Saganaga syenite (648) in full character. Much of the feldspar is pale red, and forms a crystalline mass in which the hornblende and quartz are imbedded. Some of the hornblende is partially chloritized, and crumbles under the finger nail.

Blueberry cascade and Portage, N. E. ¼, S. W. ¼ sec. 12, T. 65-4. Here is a small U-shaped bend in the river, opening south-southwest, and a portage of 20 rods passes across the opening. Here a long cascade comes roaring and foaming tumultuously down over the straggling fragments of the shattered contiguous syenitic slopes. Of this I obtained a good photographic view. The ruined hillslopes appear in every direction, and the black trunks of the sparse dead forest stand bristling along the hill-crests and lie in impassable tangles across the stream. I obtained also a good view of one of these shattered slopes.

Sterile as the region seems, it sustains an amazing growth of blueberries. One single stem bore hundreds of large and savory berries, and of this I also prepared a photograph. This crop appeared to be in full maturity when we camped here on the seventeenth of August; but it was apparently undiminished and unimpaired when we returned on the eighth of September.

Immediately above this bend in the river we encounter other rapids. These we ascend with difficulty. Syenite lines all the shores. Now follows a quiet lake-like stretch of three-fourths of a mile, and then we come to falls.

N. E. ¼, N. E. ¼, sec. 13, T. 65–4. Gunflint falls, upper (south) end of portage. The falls are wide and quite precipitous. The portage lies on the east side. Took a photographic view. The formation is Saganaga syenite. The dark mineral however, is *arranged in courses*, and the rock is truly gneissic (649). The hornblende too, is a little chloritized. The quartz grains are large but not enormous. The strike of the gneissic structure at this place is N. 80° E. The strike of the Kewatin slates where seen at sec. 22, 65–3, (as of Minn.), is N. 72° E.

The syenite here is intersected by a dike of rather peculiar diabase (822) crossing the strike.

A few rods further up the stream other rapids intercept our course, but with labor and risks we pole the canoes past them. And now the stream gradually widens into the northern arm of Gunflint lake.

§ 12.—GUNFLINT LAKE.

Gunflint lake lies on the international boundary. The American shores are included chiefly in township 65–3, west; but they stretch eastward into T. 65–2, and westward into T. 65–4. Its extreme length is nearly eight miles, with a mean width of about a mile. Its longer axis is nearly east and west. North of the western end is a considerable expansion, connected with the main lake through the "narrows," which furnish an exit northward for the drainage. This expansion extends east and west into two bays the eastern one of which I have named for reason, Black Fly bay. The width of the expansion here is over a mile and a half. The distance from Gunflint falls southward to the Narrows is one mile.

The land on the Canadian side not having been mapped nor the shore line meandered, I have referred Canadian localities to their places in the United States survey, as if extended beyond the national boundary. I have also laid down as nearly as they could be estimated, the meander lines of the Canadian shore. Relative positions of principal points have been ascertained by taking bearings with a good pocket compass. These methods, of course are rough and unsatisfactory; but one on the spot can certainly form a conception of the situation more correctly than the reader who has not been there and has no maps to assist him. With such approximation I have presented here a map of Black Fly bay, a map of Animike bay on the extreme west, south of the Narrows, and a map of that portion of the body of Gunflint lake which is geologically of greatest interest.

The physiographic environment of Gunflint lake is wild and pic esque. It lies in a rugged valley between the Giant's Range on north and the Mesabi Range on the south. The former stretches w ward to Seagull and West Seagull lakes and eastward with a tende northward, far into the interior on the Canadian side. This is lying in the southern horizon from the high elevations north of anaga lake. The Mesabi Range extends equally far toward the and west; but its main mass lies nearer the lake than that of Giant's Range. The sky-line of the Giant's Range is undulating soft; that of the Mesabi, notched, jagged and precipitous. As enter the body of the lake through the Narrows, one of the crowned ridges of the Mesabi Range lies in front. This fades ward into a high pass and this is bounded by a vertical wall on east, above which rises the massive continuation of the Range, cre characteristically by a columniform precipice. This Range, preci ous on the north, slopes gradually to Loon lake, a mile distant so ward. Five miles from the western extremity of the lake app another pass over which lies the portage to Loon lake and southw The lake terminates eastward in a broad valley furnishing exit Gunflint river to North lake. On the north of Gunflint lake str massive ridges of earthy and crystalline schists, trending diagon east-north east. Behind these rise the higher ranges of gneisses syenite.

The entire surface on the Minnesota side has been burned over, the exception of limited areas. A memorandum on the survey plat states that the burning occurred in 1860. Subsequently trembling aspen and to a less extent the white birch, have taken session of the soil-covered areas, especially along the lake sho Seen from the lake the surface of this young forest of thickly stud and verdure-clad trees presents the appearance of a vast mead which it might be a holiday pastime to traverse; but the geolo who draws near to this meadowy surface with the intent to pass yond to the brown cliffs which frown upon it from the hights, encounter steeps and slides and rocky walls and angular taluses interwoven branches all conspiring to render his ascent slow and la rious. Along the northern side much of the original forest remai but fallen trunks and thickly tangled bushes render travel even m difficult than on the American side, until we rise above the soil-cove areas to ridges of bald schists and syenite.

The shore-line on the southern side is little broken or indent One well-marked peninsula occurs and another broader-mouthed, termined by subordinate ridges of the Mesabi Range. On the north, however, the shore is deeply indented by bays and promontories.

This lake, according to the barometric observations of Prof. N. H. Winchell lies 1,052 feet above lake Superior.

Geologically Gunflint lake possesses interest which is destined to render it a classic region. It touches the confines of three unconformable systems of Archæan rocks, and brings to light facts which may probably serve to relieve many of the difficulties which have beset the investigation of the ancient formations of America. The Giant's Range on the north is composed of syenite and syenitic gneiss, the slopes of which attain the lake shores around parts of the expansion. These are flanked by crystalline schists which probably abut obliquely on the lake and these are succeeded by vertical earthy schists forming ridges which run obliquely parallel with the north shore and exhibit an instructive passage downward to the mica and hornblende schists and gneisses. These earthy schists retain all the characteristic petrographic and structural characters of the argillytes and sericitic schists occurring on Knife, Fall, Long and Vermilion lakes; and are also identical in physical characters with the vertical slates seen north of Saganaga lake.

In the immediate vicinity of the massive outcrops of these vertical slates occur the black, carbonaceous, flinty and magnetitic slates plainly identifiable with the Animike formation of Hunt, and equally demonstrated by my own observations, to be the same system of rocks as by Murray and Logan were named Huronian. But these possess but a gentle dip toward the south and are abruptly unconformable with the Vermilion and Gunflint slates. They are equally diverse in petrographic characters.

Finally, a fourth vast formation, later in origin and eruptive in character, occupies most of the surface along the south shore of the lake. It crowns and characterizes the hills of the Mesabi Range, forming high columnar precipices rising above perpendicular cliffs of Animike black slate facing north, and sending down numberless taluses of angular fragments sloping steeply toward the lake shore. The same eruptions which flooded the country on the south of the lake extended to the north The columnar hill-crests resting on nearly horizontal Animike slates occur near the western end of the lake and at several points thence eastward; but they occur also resting on the vertical slates, as seen at the great promontory of Knife lake and again on sec. 7, 65-6 on Knife lake. But, in the vicinity of Gunflint lake, the gabbro has not been found covering syenite of the Giant's Range.

This lake under the name of "Flint Lake" appears to have been traversed by Dr. Norwood in 1849; but there is difficulty in identifying his facts and localities. The formation which I here describe as Animike slate is by Norwood styled "slaty hornblende" and another rock is called "hornblende rock;" and this is represented between the slaty hornblende and a "quartz rock" described as "a short distance below" the slaty hornblende. He recognizes on the north shore a ridge of "siliceous slate somewhat chloritic," with stratification not discovered.* A reconnoissance was made along the international boundary in 1880 by professor N. H. Winchell and he has given a comprehensive general view of the geology. He noted the unconformable vertical schists on the north shore † To this subject more particular reference will be made.

More recently the shores of Gunflint lake have been examined by the geologists of the U. S. Geological Survey‡ and to their published results more especial reference will be had in my details of observations.

The report of my field observations in the vicinity of Gunflint lake will begin at the outlet on the north, and will first cover the region of the expansion, proceeding along the west shore to the Narrows, and then along the north and easterly shores in succession. It will then take the westerly, southerly and easterly shores of the main body of the lake, and lastly the north shore and its vicinity.

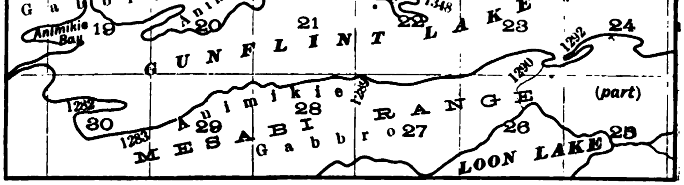

Fig. 30.—*General map of the principal part of Gunflint lake and vicinity.*
See map, fig. 41, for table of rock samples corresponding to the numbers on this map.

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* Norwood, in D. D. Owen's *Geological Survey of Wisconsin, Iowa and Minnesota*, pp. 416-417

† N. H. Winchell, *Ninth Ann. Rep Geol. Surv. Minn.* (1880), *p.* t2.

‡ See especially R. D. Irving, *Amer. Jour. Sci.* Oct. 1887.

(1). *Gunflint lake. The Expansion.*

The general features of the expansion may be learned from the small map. Figure 32, beyond.

N. E. ¼, N. E. ¼, sec. 13, T. 65–4. Here a shattered bluff of syenite attracts attention. The blocks lie along the shore in enormous masses. A photographic view was taken from a small island facing the scene.

S. W. ¼, S. E. ¼, sec. 13, T. 65–4. Bottom of western bay of the expansion. The northern shore of the bay presents continuous and conspicuous outcrops of syenite (650). At this point is good Saganaga syenite in an enormous outcrop.

North line, sec. 23, T. 65–4, head of bay. Here are only syenite bowlders.

N. E. ¼, N. E. ¼, sec. 24, T. 65–4. South side of same bay. Saganaga syenite outcrops.

N. E. ¼, sec. 24, T. 65–6. A few rods further south.

Seeing a curious crest-like formation at summit of the hill south of this western bay, I undertook to visit it. One-third of the way up, an overturned tree exposes some slaty fragments which prove to be largely magnetite—but partly changed into hæmatite. I had seen a similar stray piece of slaty magnetite at Gunflint falls.

Rock 651. Magnetitic schist fragments.

Fragments of slate as I proceed are frequently seen turned up by fallen trees; but syenite bowlders are abundant on the surface.

In one place the magnetic rock (652) was solid, and had a graywackenitic aspect.

S. W. ¼, N. E. ¼, sec. 24, T. 65–4. Near the crowning crest.

The slate becomes flinty (653) with evidences of a near outcrop.

Near here are many fragments of a diabasic character, judging from microscopic appearance.

Rock 653. Diabase or noryte, near the crest.

N. E. ¼, sec. 24, T. 65–4. On the crest half a mile south of the bay. An outcrop of clearly igneous rock, rising in a precipice facing northward, and ending in an escarpment on the west. There is a fine variety having the external aspect of diabase (655). There is a coarser variety with tabular feldspar crystals weathering pale greenish; with masses (not lamallæ) of a black mineral probably augite, and a conspicuous amount of a black shining mineral which is probably magnetite. I think the coarse variety may be called gabbro (654).

N. E. ¼, sec. 24, T. 65–4. On the return, at summit of the northern of the two ridges, I find in place, a rock inclosing schistic pieces, and otherwise consisting chiefly of grains of magnetite, with an interstitial medium of light color looking like plagioclase, and in places shining like quartz—656.

The summit of the crest visited is level for four or five rods, then a depression southward, then another level space of four or five rods.

A few rods further east I made another ascent of this hill in company with N. H. Winchell, after having studied all other points in the vicinity of Gunflint lake. I made another traverse of this ridge between Animike bay and the western bay of Gunflint swell or expansion. Syenite bowlders are abundant on the shore, and continue up the slope to the very summit. About one-third of the way up, Animike slate fragments appear. On the first low ridge, are large fragments of a rock looking like undeveloped "muscovada" (823), and in contact with magnetite. Compare with rock 656.

Rock 824. Magnetite in contact with 823.

This outcrop undoubtedly corresponds with that before seen by me at N. E. ¼ sec. 24, rock 656, further west.

A little farther up the hill are many large masses, evidently not far out of place, of a rock substantially a quartzyte (825). I have seen it elsewhere in connection with Animike slates. It consists of spherical grains of glassy quartz cemented by a white groundmass, and on a weathered surface looks finely oölitic.

S. E. ¼ N. E. ¼ sec. 24, T. 65-4. Proceeding westward along the summit of this ridge, we saw a gabbro ridge a little farther north and visited it. This, undoubtedly is the gabbro cliff seen by me before—rock 654—but approached now from a different direction. The bluff here is about ten feet high, and of coarse characteristic gabbro. This rests directly on little altered, thin-laminated slate in a horizontal position, and forms the most northerly illustration seen about Gunflint lake, of the juxtaposition of gabbro and Animike slate. We did not however, see the formations in place nearer than fifteen inches of each other; but we saw the slate in several places, as high as the bottom of the gabbro in other places.

The layers of the slate are of two kinds; 1st, a black, carbonaceous, iron-bearing rock; 2d, a heavy light gray rock. Both kinds are often opposite sides of the same laminæ. Both kinds are equally heavy. This iron is not magnetic, but in the bluff, a cause exists of disturbance of the needle.

Rock 826. Gray and black iron-bearing Animike.

We examined the fragments of slate fallen down from the cliff, in pe of some trace of organic remains; but found nothing. There rever, a curiously fitted and scrobiculate surface on some of the which I took for subsequent study.

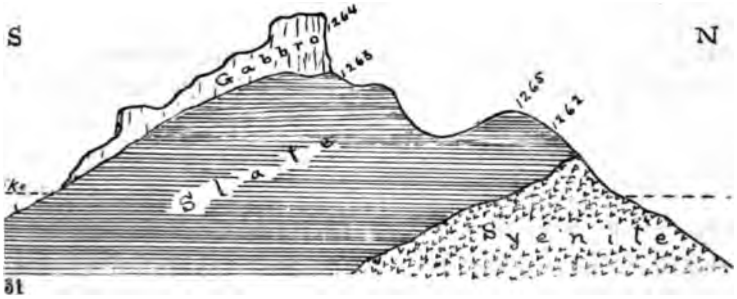
k 827. Animike slate with scrobiculate surfaces.

his place occurred, also, as I have seen elsewhere in the Animike surfaces of laminæ covered by concave depressions of an ovoid erical character, resembling what the elder Hitchcock named *hoides nidificans.* I have discovered that spheroidal concretions n laminæ sometimes cause such appearance.

k 828. Cherty concretions producing *Batrachoides nidificans.*

. ¼ N. W. ¼ sec. 19, T. 65-3. At the narrows, American side. bbro which covers the hill just described, abuts on the shore in asaltic forms 20 to 25 feet high. The level of the base of the here is fifty feet or more below the base on the crest of the rest of the narrows. This fact furnishes evidence that the gab- wed over a surface already deeply eroded. I shall present in port much more evidence of the same purport.

ady of this gabbro-crowned ridge of Animike slate, supplement- an examination of the slope along the north side of Animike be described) points toward relations set forth in the following n:



31

.—*Relation of gabbro, slate and syenite near the narrows of Gunflint lake.* Sections from north to south.

.—The numbers expressed on the diagram indicate the places where rock were collected, as follows:

he locality for rocks 651-2. 1263 is the locality for rocks 652 (bis)and 653
" " 656 1264 " " 654-5

N. H. W.]

rning now to the north shore of Gunflint Swell, we find Black r resting on the flanks of a syenitic ridge belonging to the Range.

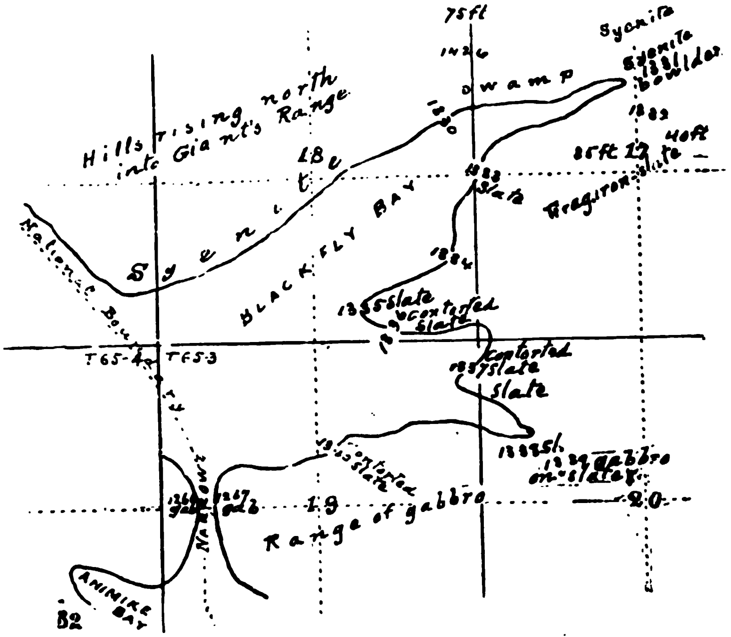


Fig. 32. *Map of localities around Black Fly bay, northwest part of Gunflint lake.* (The territory is Canadian but the lines of the American land surveys are extended over it.)

NOTE.—Locality numbers correspond to rock samples as follows:

1330	shows the locality for rock		716.	1336	shows the locality for rock		720-21.
1426	"	"	819-21.	1339	"	"	722.
1332	"	"	717-18.	1267	"	"	655 bis.
1333	"	"	719.				

[N. H. W.]

Sec. 18, T. 65-3, as of Minn. Well developed syenitic gneiss (716) along the shore, with medium-sized quartz grains. The constituents have a gneissic arrangement. The same continues to the extremity of the singularly prolonged narrow point of the bay.

N. E. ¼, sec. 18, T. 65-3. Ridge of syenitic gneiss north of Black Fly bay. Examined carefully at many points and as far as the summit. The rock has a sort of groundmass of reddish and whitish feldspar, with irregularly elongated cakes of quartz, all disposed from east to west, with only a little hornblende, and that not well formed. On the whole, it much resembles the gneiss of sec. 12, 65-3 W., as of Minn., rocks 806-14, (which see beyond). It further resembles it in containing *fragments of hornblende schist,* which are all disposed in the same direction. I feel a strong confidence n the opinion that if

approach between the gneiss and the probable southward
in schists were not covered by this bay, we should witness
d of a transition from one to the other as certainly exists
east end of Gunflint lake. (See descriptions further on.)
t improbable that such transitions sometimes occur along
trike of the schistic formation.

. Syenite gneiss.

. Hornblende schist pebble in the gneiss.

. Contact of last two.

oint of Black Fly bay. Beyond this a valley continues
atly obstructed by syenitic bowlders. There would have
pect of finding the rocks which intervene between the
he Animike hill on the south if time had been sufficient
land exploration. Leaving the valley I ascended the hill
side of Black Fly bay. It seems at first almost formed
owlders, largely of the Saganaga variety of syenite.

sec. 17, T. 65-3, as of Minn. On the hill and hillside
ck Fly bay. Proceeding westward along the hillside just
est, in search of an outcrop of syenite or of slate, I found
f slate.

urther along, large fragments of iron slate dipping still
ttle disturbed. Continued a quarter of a mile along this
g slate fragments in extreme abundance, but not any un-
dge.

. Magnetitic slate fragments, as above.

. Granular or oölitic magnetite.

ess is seen in the oölitic magnetite, but it is included in
rmation.

sec. 17, T. 65-3, as of Minn. Outcrop of slate by water's
7°, S. 20° W. (by needle). This is about sixteen rods from
on the north side of the bay. The slate is banded and
'19). It is the nearest seen to the syenite.

sec. 18, T. 65-3, as of Minn. Slate having same appearance

sec. 18, T. 65-3, as of Minn. Extremity of cape in eastern
ack Fly bay. Rough slate dipping 7° southward.

sec. 18, T. 65-3, as of Minn. Just south of the cape. A
e display. In a rounded, naked bluff fifteen feet high, is
aspect of a conglomerate, with many whitish constituents.
ion shows it to be a portion of the slate formation contorted
ng manner. The laminations are still presented, and serve

to evince the disturbance. There are some quartzose layers, and some quartz veins. Much of the slate has assumed a flinty constitution, and some laminæ are of red jasper. There are patches of what I have called oölitic magnetite, and areas in which the spherules are sparsely scattered in a somewhat homogeneous matrix of undetermined character. In some places, the crystalline magnetite sparkles brilliantly, and there are others in which it has been oxidized by water and burnings, into a crumbling, ferruginous mass, like the waste of a hæmatite mine.

Rock 720. Various examples of the slate of the formation.

Rock 721. Magnetite in its various conditions.

It does not appear whether this disturbance has resulted from action of the contiguous syenite or the equally contiguous gabbro. With some probability, however, it is connected with the gabbro overflow. Yet another explanation remains.

Observations elsewhere prove that the syenitic gneiss is older than the Kewatin slates and that these are older than the Animike slates; while the gabbro is more recent than the latter. Disturbances of the Animike therefore must be attributed to the latter. But it is by no means certain that the flinty and jaspery contortions above described could have been caused by an overflow of gabbro.

Neither does it appear probable that the magnetite is accumulated in quantities of commercial importance. Every occurrence is local and limited. An unlimited quantity is held in the formation; but like the magnetite of Penokee Gap, it is too much dispersed.

N. E. ¼, N. E. ¼, sec. 19, T. 65-3, as of Minn. Altered slate like that last described.

N.W. ¼, sec. 20, T. 65-3, as of Minn. Seeing a high crag off the head of this little southeastward projecting bay, I landed to visit the spot. Here a ledge of magnetitic slate outcrops.

S. W. ¼, N. W. ¼, sec. 20, T. 65-3, as of Minn. The crag proved to be an enormous buttress of coarse gabbro resting on well laminated slate, and presenting the striking profile exhibited in part in the diagram, fig. 33.

Much of the slate is flinty, and most of it contains much magnetite (722). Some of the gabbro is very coarse and tends to decay; the finer is more solid. There are patches showing large parallelopipedons of feldspar—like the sanidine in the trachyte of the Drachenfels. It tends toward rude columnar shapes, some of which are quite imitative of true basalt.

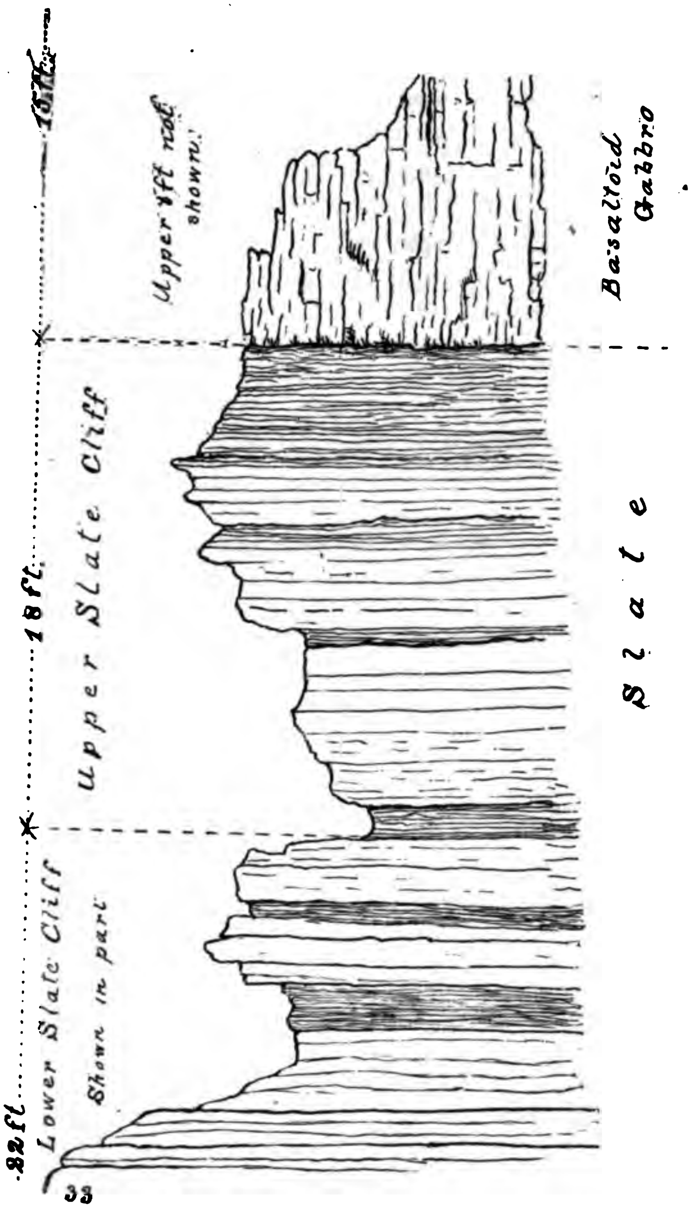


Fig. 33.—*Gabbro-crowned Animike cliff, near Black Fly bay of Gunflint lake.*

N. E. ¼, sec. 19, T. 65–3, as of Minn. Contorted slate. Gabbro can be seen on the hill in the background.

At the narrows, east side. Gabbro (655 bis) as already described on the west side. The gabbro crowning the hill north of Animike bay continues in the hill south of the body of Black Fly bay; and probably continues into the high bluff visited in the N. W. ¼, sec. 20, T. 65–3, as of Minn.

(2) *Gunflint lake, west, south and east shores.*

From the narrows the basaltiform gabbro continues into the mouth of Animike bay.

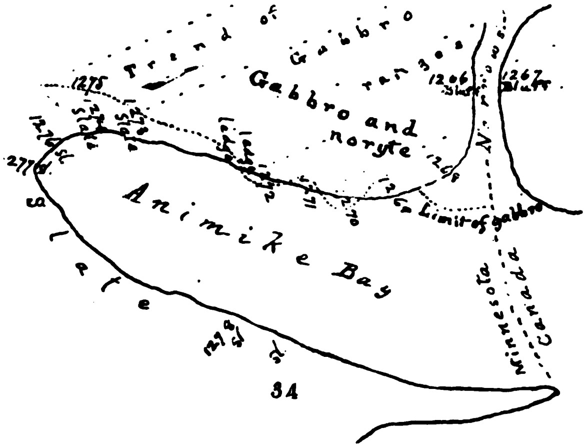


Fig. 34. *Localities in the vicinity of Animike bay, Gunflint lake.*

Halt numbers on this map correspond as follows to rock samples collected: 1267 to rock 655 bis, 1268 to rock 656 bis, 1269 to rocks 657-9, 1271 to rock 660, 1272 to rocks 661-3, 1274 to rock 664, 1275 to rocks 665-71, and 1276 to rock 672. N. H. W.

S. W. ¼, N.W. ¼, sec. 19, T. 65–3. Diabase (or noryte) inclosing nodules of pale, amber-colored striated feldspar.

Rock 656 (bis). Diabase (noryte ?) with much magnetite. Perhaps only a very fine condition of the gabbro.

S. W. ¼. N. W. ¼, sec. 19, T. 65–3. Mouth of Animike bay, north side. Rock like rock 656 in structure, but without magnetite—having a feldspathic ingredient instead. Many small fragments of black mineral sometimes resembling charcoal—perhaps anthracite. In places it holds a multitude of rounded pebbles, and forms a conglomerate with a cherty groundmass. Generally it contains magnetite in such places, and this is sometimes accumulated in much purity. The following specimens illustrate the varieties:

Rock 657. Fine gabbro without magnetite.

Rock 658. Conglomeritic variety as above.

Rock 659. Magnetitic specimens.

This formation, in spite of its massive appearance, in many places is really bedded. One of the specimens of 659 shows it. On making a trip up the hillside, I find places really slaty, and partially argillitic, but generally magnetitic.

The bedding of this formation is nearly horizontal. All the large fragments near the shore, too fresh and angular to have been much moved from place, are horizontally bedded. Not a fragment stands on edge. On the hillside, the outcropping ledge appears quite clearly to possess horizontal bedding.

So much then is settled:—these are characters of the Animike formation.

N. E. ¼, S. W. ¼, sec. 24, T. 65-4. Four rods along the shore westward, the noryte comes to the shore; as it also does six rods east of the last locality.

N. E. ¼, S. E. ¼, sec. 24, T. 65-4. North shore of Animike bay, a few rods further westward. Horizontal magnetite slate (660).

This bears an extreme resemblance to the magnetitic slates of Penokee gap—as the latter slates reminded me when there, of the Huronian slates north of lake Huron which I had then recently examined.

N. E. ¼, S. E. ¼, sec. 24, T. 65-4. North side of Animike bay. The ledge of noryte comes to the shore again, standing in great vertical flakes. But fifteen feet west, finely characteristic slate, well banded and tending readily to split, is seen resting in place (661), in a horizontal attitude. This is clear, and incapable of question. The formation is rather flinty.

Immediately under these banded slates is a massive layer of almost pure magnetite (662) at least fifteen inches thick.

These observations show that the slates seen on the northern slope of this hill are of this formation, and that they repose on the syenite, at least on the north side, and have been overflowed by gabbro from vent remote or contiguous. A section across the hill would be therefore as already shown in fig. 31. The following observations confirm this conclusion.

Rock 662. Magnetite in a band fifteen inches thick, as mentioned above. It breaks into flakes at right angles with the bedding.

Rock 663. Magnetite from the laminated portion.

Near western extremity of Animike bay.

The slates outcrop in a low ledge on the immediate shore, and show a dip nearly south, or a little east of south, at an angle of 5°, as shown below.

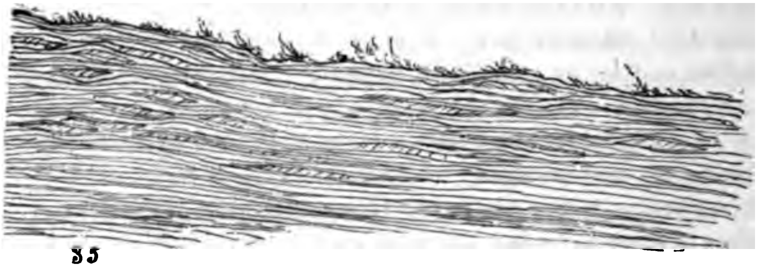
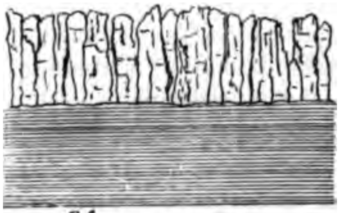


Fig. 35. *Exposure of Animike slate near head of Animike bay, Gunflint lake.*

S. E. ¼, S. E. ¼, sec. 24, T. 65-6. North of extremity of Animike bay. Twelve rods from the water, on the hillside, the slates outcrop in a thinly laminated condition (664). I counted 115 laminæ in the space of twenty-two and a half inches. The formation has a dip of 8° toward S. 20° E. It is quite magnetitic.

A few steps further up the hill. Here we have a clear demonstration of an overflow of noryte and gabbro on the slate. The following drawing was made on the spot, fig. 36.



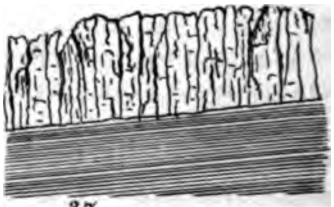


Fig. 36. *Relation of basaltiform gabbro and slate, near head of Animike bay. Looking north.*

Fig. 37. *Relation of basaltiform gabbro and slate, near head of Animike bay. Looking west, and showing dip of the slate.*

The gabbro near the contact is charged with magnetite, but a few feet above, it is quite characteristic. The slate also becomes harder and more magnetitic near the contact.

Rock 665. Slate 1½ inch from gabbro (Ticket is on upper side.)
Rock 666. Magnetitic slate in absolute contact.
Rock 667. Gabbro in contact with 666.
Rock 668. Gabbro five or six feet higher than 667.
Rock 669. Gabbro six inches above 667.
Rock 670. Gabbro twelve inches above 667.

Rock 671. Gabbro eighteen inches above 667.

Head of Animike bay. Here within eight rods of the shore, is another contact of a similar kind, which is exposed for a distance of more than 75 feet.

Rock 672. Magnetitic slate a foot below contact with gabbro.

South of west extremity of Animike bay. A hill here 75 feet high is composed of slates similar to those seen in fig. 35.

The outcrop extends to the shore.

S. W. ¼, sec. 19, T. 65–3. Middle of south shore, Animike bay. Slate, considerably crumpled and broken; but this may be an incident of denudation.

Close by this, eastward, a larger outcrop, less slaty than usual, including large lenticular compact portions.

The next small bay south of Animike is not represented on the plat, and is separated from Animike by a long spit also not represented. Into the head of this little bay empties a deep and slow-flowing stream up which I ascended until canoe navigation was interrupted.

N. E. ¼, N. E ¼, sec. 25, T. 65–4. About a third of a mile up the river, in sec. 24, on the the south side, is a high cliff of slate, in a nearly horizontal position. I did not ascertain whether gabbro is at the top.

A great quantity of magnetitic slate has fallen down in a talus.

On the north bank of this stream, the magnetitic slate makes a low, smooth-surfaced outcrop, giving the appearance of graywacke; but examination proves its character.

Memorandum —According to the testimony of Mr. Buddle, an intelligent explorer and mine master, the same horizontal condition of this formation continues through sec 23, T. 65–4.

N. E. ¼, sec. 25, T. 65–4 Magnetitic slate in great solid masses—Rock 673.

N. W. ¼, sec. 30, T. 65–3. West end Gunflint lake. Here is the extraordinary occurrence of a sandy beach.

Here I found camped a party of explorers for iron. Mr. Buddle, in charge informed me that in sec. 23, T. 65-4, he had uncovered magnetic iron ore for a distance of 1,600 feet. It lies almost horizontal, and is similar to that seen in sec. 24. This is all to the south of the Giant's Range (v. page 80).

A gap through the Mesabi Range south of, here, which makes a conspicuous feature in the southern horizon as viewed from the narows, is limited on the east and west by corresponding precipitous esarpments and seems to be a suitable place for a trail southward. The

Indians consider the gap as caused by a subsidence. The cliff on the west is undoubtedly an interruption of the ridge visited about a third of a mile up the river in sec. 24. It does not appear from a distance that this range is gabbro-crowned; but from other positions along the lake the gabbro is obvious.

N. W. ¼, N. E. ¼, sec. 30, T. 65-3. North side of long point. Slate occurs all along this point and at the extremity. I made an excursion to the summit of the ridge, but found no indications of eruptive rock.

N. E. ¼, S. E. ¼, sec. 30, T. 65-3. Main shore south of point. I determined to visit the cliff about half a mile inland. This is a continuation of the ridge mentioned on sec. 24. About half the way up I found slate.

S. E. ¼, S. E. ¼, sec 30, T. 65-3. At foot of cliff. This proves to be gabbro (674) of the coaser sort. The cliff is about 15 or 18 feet high above the talus.

N. E. ¼. N. W. ¼, sec. 32, T. 65-3. At summit of hill. The outlook from here is wide and full of scenic interest. Looking northward, a range of mountains stretches east and west along the horizon, apparently six to ten miles distant. From the west it reaches to the river entering the northern swell or expansion of Gunflint lake, gradually lowering as it approaches the stream. White rocks can be seen exposed at numerous places. The same range extends on the east or Canadian side of the stream, and its slopes are very frequently marked by white syenite exposures. These hills are part of the Giant's Range.

In the nearer foreground are seen the narrows and the mouth of Animike bay and the shore-line features toward the east.

I made a sketch of this interesting landscape, and afterward decided that it ought to be photographed. Accordingly I returned to the canoe and brought photographic apparatus and Mr. Grant, and the event proved that the views obtained were entirely satisfactory. They are reserved like others for the final report.

N. W. ¼, N. W. ¼, sec. 28, T. 65-3. To this point, a mile from the point on the shore at which the cliff was visited no outcrops were seen. The slope is denseley covered with young poplars. Here is a ledge of slate four or five feet high, rather thin-laminated.

N. E. ¼, N. W. ¼, sec. 28, T. 65-3. No outcrop is found here, but it seemed best to examine the fragments. They are mostly gabbro, of the variety which occurs a short distance above the slate. But some are massive magnetitic layers from the slate. The latter, to the eye, much resembles the former. Here also are some samples of the coarse gabbro.

Rock 675. Magnetitic rock, apparently from the slate.

Rock 676. A peculiar variety of gabbro.

N. W. ¼, N. W. ¼, sec. 27, T. 65-3. Small point on south shore The beach is strewn with a great assortment (677) of striking pebbles —mostly flinty and jaspery, and evidently derived from the slate.

Rock 677. Collection of jaspery and flinty pebbles.

Rock 678. Curiously banded flint pebble.

S. E. ¼, S. E. ¼, sec. 23, T. 65-3. Near west point of strait to small elongated bay, south side. A couple of rods back from the shore is a bluff of gabbro (679). It seems unusually heavy.

This bluff does not break down and form any talus.

The wall of gabbro continues east and strikes the shore before reaching the extremity of the point.

S. E. ¼, S. E. ¼, sec. 23, T. 65-3. Extremity of point at strait. Gabbro much finer than No. 679, and much less characteristic (680); but it is a prolongation of the back part of the same bluff.

Opposite (east) point of strait. Continuation of gabbro, forming a knob 60 feet high. This gabbro ridge appears to be the running out of the high range visited N. W. ¼, N. W. ¼, sec. 32, 65-3, and in which occurs the abrupt notch through the Mesabi range referred to.

The course of the range is less eastward than the axis of the lake. Hence all gabbro ranges, both sides of the lake, as will appear, make a small angle with that axis—those on the south side retreating inland toward west by south or west southwest, and those on the north side retreating inland toward east by north or east north-east. But back (south) of the range which runs out at this knob rises another similar and parallel range, on the south side of which lies Loon lake.

About a mile east of this bay occurs another, entered through a broader strait.

S. W. ¼, S. W. ¼, sec. 19, T. 65-2. Farther (eastern) point of the bay. No outcrop of rock; but a bowlder beach.

S. W. ¼, S. W. ¼, sec. 19, T. 65-2. Commencement of eastern end of Gunflint lake. Gabbro (681) in a low outcrop at the beach. All the shore along here is strewn with angular fragments resembling the same.

N. W. ¼, S. E. ¼, sec. 19, T. 65-2. A gravel beach presenting a gray appearance with the diversified colors of its pebbles blood-red, dull-red, banded, black, gray and white, all siliceous; many of them are beautifully translucent flint; others the most fine-textured jasper.

Collected an assortment (682). All these must be in place somewhere on the north shore, or below water-level, for they certainly do not so occur along the southern shore.

The remainder of the eastern end of the lake presents no rocky outcrops Two low green points extend into the lake, bowlder-covered and sandy. A chain of small islands lies between them, and these appear to be simply bowlder-formed.

(3) *North side of Gunflint lake.*

It will be most convenient to return to the Narrows and follow the north shore toward the east.

N. E. ¼, sec. 19, T. 65-3, as of Minn. Low outcrop of dark rock appearing stratified vertically; and I can find no trace of other stratification. Still, this fine, almost aphanitic, diabase-looking rock (723) belongs to the slate formation. It contains much magnetite, and the lighter mineral looks more siliceous than feldspathic.

This condition of the Animike is to be compared with that seen on the north shore of Animike bay, especially Rock 662 from a locality not more than half a mile distant. The massive rock seen on the river shore too, with a smooth-surfaced outcrop is similar. These may all be outcrops of the same bed.

S. E. ¼, sec 19, T. 65-3, as of Minn. Outcrop similar to the last. These are striking examples of the complete disappearance of the sedimentary structure and its replacement by a system of parallel jointage in a position nearly vertical to the original bedding.

On a later occasion I visited this locality for the purpose of assuring myself that the vertical structure does not pertain to an outcrop of the vertical slates seen farther east on this shore. The following are my notes on the second visit. "The formation is not Kewatin. What I have said is correct. Although the rock is so dark and heavy, it does not affect the needle. I suspect much anthracite or graphite mingled in it.

Rock 817. Dark massive Animike.

"It is not improbable that the rock is on the border line between Animike and gabbro. However, in travelling along the north shore of Animike bay again, I notice that an identical rock is embraced *within the slates.* I obtained another hand specimen of Rock 662. It is almost incredible however that the mass at S. E. ¼, sec. 19, 65-3. should be inclosed in the slates; and the jointed condition is also against the supposition. It must be concluded that almost identical rocks are embraced in the slates and the gabbro."

Memorandum.—This is probably correct. In many places subsequently visited the line of the junction between gabbro and slate was very uncertain. Each formation has exerted an action on the other. This is revealed in approximate mineral constitution and rock structure. A rude columniform arrangement often appears in the slates for several feet below the contact. In other places however, the evidence of mutual influence is wholly wanting.

S. W. ¼, sec. 20, T. 65-3, as of Minn. Slate, exposed along the slope of the hills. In one place it presents a dip of 21°, N. 20° E ; but it varies locally, and I feel persuaded that it has fallen or slid out of position. Farther along (eastward) it dips in various directions; and, in the course of 16 rods, it presents the crumpled and altered condition of the slate seen at sec 18, 65-3, as of Minn., rocks 720-721. The shore is strewn with angular fragments of the banded flinty slate.

N. W. ¼, sec. 21, T. 65-3, as of Minn. The formation here is in the condition of a breccia consisting of angular fragments of magnetic slate (723 bis and 818) imbedded in a matrix of finely granular rock.

This breccia crumbling to pieces makes the pebbly beach around the point.

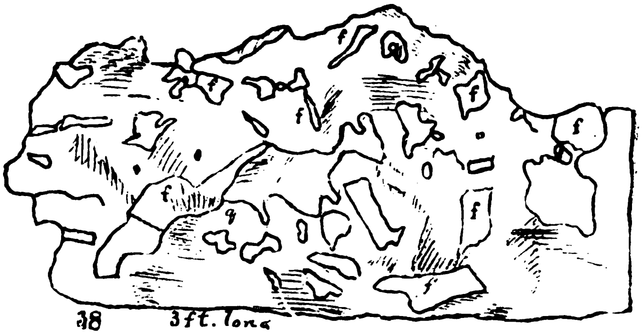
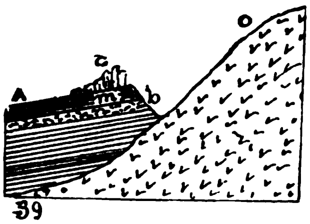


Fig. 38. *Brecciated condition of the Animike formation, north side of Gunflint lake.*

The brecciated condition can be seen along the shore for a quarter of a mile.

These localities of breccia are about a mile and a half nearly east from the interesting locality in Black Fly bay. They are all apparently outcrops of the same horizon in the Animike. The horizon is not far from the contact with older terranes; but this does not prove the brecciated bed and the (newer) magnetitic bed to hold positions near the base of the Animike. They may, on the contrary belong near the top of the Animike. But the proximity of the gabbro to the magnetitic bed would not prove this, since the gabbro simply rests on what was the actual surface at the time of overflow. The slight southward dip of the Animike, however, would indicate that the breccia and magnetite belong to the later stages of the period.



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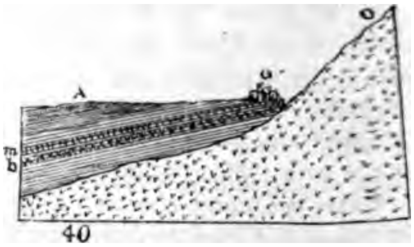

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Figs. 39 and 40. *Two supposable relations of the Breccia and Magnetitic bed in the formation.*

A, Animike; G, Gabbro; O, Older terrane; m, Magnetite; b, Breccia.

The relation of the Animike to the older formation, which is shown in Fig. 39 explains how the proximity of *m* and *b* to O would be conformable with the theory that they belong in the *upper* part of the Animike. It implies that the Animike was deposited on a sinking sea-bottom—as on other grounds was probably the fact.

The relation of the Animike and older formation, which is shown in Fig. 40 explains how the proximity of *m* and *b* to O would be compatible with the theory that they belong to the *lower* part of the Animike. It implies that after the deposit of the Animike, the contiguous land was uplifted.

Observation shows that the dip of the Animike is not conformable with the visible or probably the conceded slope of the surface o the older terrane as in Fig. 40, but that it is unconformable, havin very gentle dip southward, as in Fig. 39. Hence reasoning from facts thus far presented it may be concluded that the magnetitic is near the top and not near the bottom of the Animike, as has be suggested for the Thunder bay region.

Sec. 21, T. 65-3, as of Minn. Animike beds containing, as nearly I can judge in the field, a large proportion of iron carbonate.

Rock 816. Iron carbonate with argillaceous and siliceous matt as macroscopically determined.

Sec. 16, T. 65-3, as of Minn. Ascended a small hill forty r back from shore, thinking possibly it might be the terminal kno the range of vertical slates exposed a mile east of here. It prove be underlaid by Animike. So far as I found rocks in place, I saw only a gray ledge somewhat resembling "muscovado." It seems to be composed of fine quartz and feldspar with glistening scales like sericite. There are rusted surfaces which indicate also, as I think the presence of iron carbonate.

Rock 815. Incipient muscovado?

N. W. ¼, sec. 22, T. 65-3, as of Minn. A knob of gabbro resting on Animike slates. This continues near the shore, and finally, on a change in trend of coast line, retreats across the country,

N. W. ¼, sec. 22, T. 65-3, as of Minn. A low outcrop of a dark gray rock (724) similar to that at sec. 19, 65-3, as of Minn., (the magnetitic bed), and similarly jointed. But examination shows a coarser texture and some recognizable faces of dark augite. If this belongs to the Animike the rock is highly altered. It may be a portion of the gabbro immediately superjacent. Following my usage I shall designate it noryte (?).

N. E. ¼, sec. 22, T. 65-3, as of Minn. At the point of a long slender peninsula setting east southeast from the main land. A pile of thin laminated slate going to decay.

N. E. ¼, sec. 22, T. 65-3, as of Minn. Small islet of medium grained gabbro. It is cut by divisional planes running N. 60° E. into great sheets which stand like piled lumber dipping at an angle of 82°.

This is a mass of gabbro at the water level, and its continuation half a mile westward would bring it into the position of the so-callde "noryte"? rock 724.

N. E. ¼, sec. 22, T. 65-3, as of Minn. Main land directly opposite the gabbro islet. Here is a genuine surprise. Here are true argillytes (725 and 789) standing nearly vertical. They are not at all ambiguous. They are the Knife Lake slates preserving to this point, their steady verticality, and here remaining uncovered by Animike. This looks like a solution of a vexed problem. The Animike and the Vermilion slates *are not one.*

Here is no magnetite structure. The dip is S. 89°. The strike of the sheet is N. 72° E.

This spot was visited four different times. I discovered that the broad sides of the vertical sheets were sometimes marked by a "grain" like that of wood; and that it presented a pretty uniform dip of 67° eastward.

Rock 729. Slate showing sedimentary structure and grain.

These vertical slates appear close by the water's edge, the exposure being the front slope of a hill about twenty feet high. It seemed desirable to ascertain what lies back of this hill on the landward side. So crossing an intervening swampy depression I ascended the first higher hill.

S. E. ¼, sec. 15, T. 65–3, as of Minn. Summit of range one-fourth mile back from shore. Here are the ashen-bleaching argillytes. The color may be due to sericitic matter, for that is obviously present in places. Their dip is 67°, varying to 74°, in direction S. 21° E. They present a very familiar aspect. Rock 726.

Other eminences in the east and west continuation of these two ranges could be seen, presenting the same argillitic color and aspect. A higher range also now appeared farther inland, the rock exposures on which were evidently similar to those of the two front ranges. But no opportunity existed at the time for penetrating further. A subsequent exploration by Mr. Stacy will be referred to in the sequel.

The following sketch-map has been prepared for the purpose of showing as precisely as possible the interesting facts observed respecting the relations existing between the vertical argillitic slates and the Animike slates:

The locality numbers, expressed on the map, next page, correspond to the following rock numbers:

1298	indicates	the locality	for rock	688-90	1361	indicates	the locality	for rock	737
1346	”	”	”	724	1362	”	”	”	738–40
1349	”	”	”	725	1364	”	”	”	741-2
1350	”	”	”	726	1418	”	”	”	799
1351	”	”	”	727	1419	”	”	”	800–3
1356	”	”	”	728–9	1420	”	”	”	804
1357	”	”	”	730	1422	”	”	”	805
1358	”	”	”	731	1423	”	”	”	806–14
1359	”	”	”	732-6	1424	”	”	”	815

[N. H. W.]

N. E. ¼, sec. 22, T. 65–3, as of Minn. The Kewatin slates are a little sericitic—rock 727.

N. E. ¼, sec 22, T. 65–3, as of Minn. Vertical argillyte continues:

N. W. ¼, sec. 22, T. 65-3, as of Minn. Vertical argillyte. The formation continues in the hill four rods back from shore, as far as the head of little bay, and further strikes toward the main shore of the lake. But I have not been able to find these slates along the shore west of the cape. Every exposure in front of this now reveals Animike. But I feel confident the Kewatin could be traced overland far toward the head of Black Fly bay, where the Animike comes within a few feet of the syenite. The Kewatin would thus be found passing under the Animike.

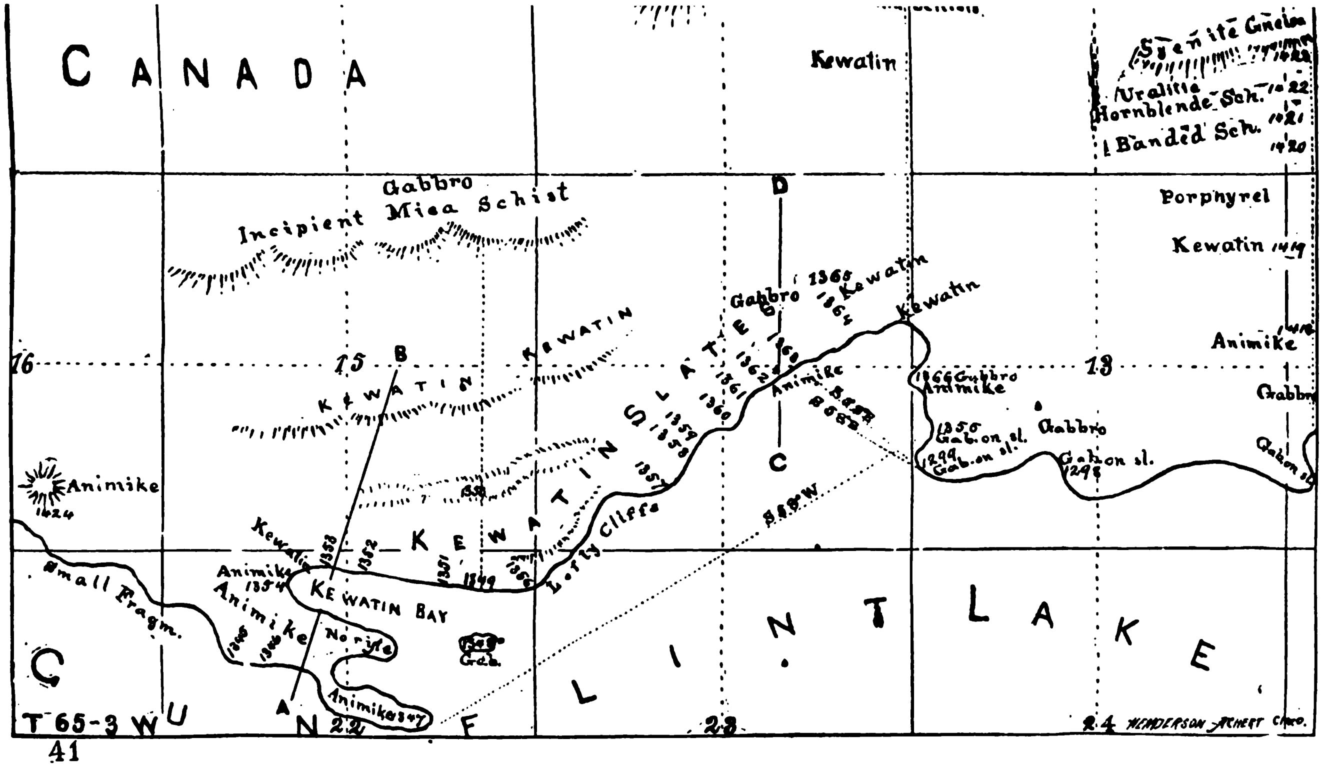

Fig. 41. *Map of a portion of the north shore of Gunflint lake embracing the principal exposures of the vertical slates, and showing their positions relative to the Animike series.*

The survey-lines are extended over from the American side.

N. W. ¼, sec. 22, T. 65-3, as of Minn. This is the nearest approach of Animike exposures to Kewatin exposures in this direction. Here are thin laminated slates with a low dip southward. This point is less than an eighth of a mile from the last.

The following diagram evidently illustrates very nearly the structural relations of three contrasted terraces occurring in this vicinity:

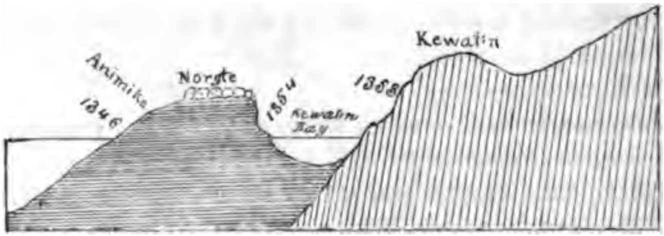

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Fig. 42. *Illustrating the relations of the Kewatin, Animike and Noryte on the north shore of Gunflint lake. Being a section along the line A B on the sketch-map, fig.* 41.

In figure 42 the number 1346 shows where the rock sample 724 was collected.
N. H. W.

N. E. ¼, sec. 22, T. 65-3, as of Minn. High vertical bluff of sericitic argillyte—728.

The bluff presents a series of rock slates facing almost exactly south, and standing in a position precisely vertical. But there is a grain seen on each face, which dips 57° eastward. One might at first suspect this to denote the true sedimentary bedding. The objections to this view are the facts that no contrasts of color or texture are noticeable in the direction across these lines, while in the direction across the vertical plates contrasted bands of color and texture can be plainly seen. The rock specimen 729 taken here shows both structures. The same is true of 730 and 736. Further, no laminations or separable beds exist in conformity with the grained structure. It remains then to inquire after the cause of such structure.

S. W. ¼, sec. 14, T. 65-3, as of Minn. Another high cliff presenting vertical slates sidewise to the lake, but a little obliquely. It is a soft argillyte of a pale blue-gray color. Strike of the slate N. 42° E. Dip of the obscure grained structure 50° northeastward.

Rock 730. Argillyte showing both bedding and graining.

S. W. ¼, sec. 14, T. 65-3, as of Minn. Sericitic argillyte (731) studded with quartz grains.

This is not well marked sericitic argillyte. It closely resembles the vertical slates along the IVth Arm of Knife lake which were named provisionally porphyrellyte. This then would be quartz porphyrel. It may prove to be parophitic.

S. W. ¼, sec. 14, T. 65-3, as of Minn. Sericitic argillyte (732) densely studded with quartz grains an eighth of an inch in diameter. Otherwise this rock is like 730.

Other portions of the formation are similarly studded with grains f red feldspar

Rock 733. Porphyrel.

Some other portions abound in both quartz and feldspar. These rtions have a distinctly schistic groundmass exactly as in IVth rm of Knife lake, and become more characteristically porphyrel.

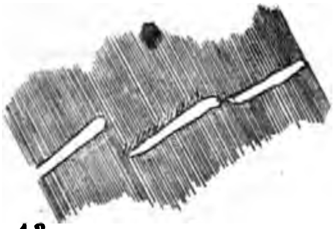
Rock 734. Porphyrel with feldspar and quartz.

A vein of white, opaque quartz (735) intersects the formation, about inches wide and lying in a plane dipping S. 50° W. at an angle of out 22°. This dip however, is merely local.

The plate structure (dynamic structure) trends N. 64° E. and is ctly vertical. The fibrous structure dips at an angle of 62° east-rd.

Rock 736. Plain schist showing both structures.

E ¼, sec. 14, T. 65-3, as of Minn. Quartz porphyrel with grained cture dipping 66° eastward. The figure below illustrates a faulted rtz vein exposed in the face of one of the slabs of the formation.



43

43. *Faulted quartz vein. The lines show the eastward-dipping grained structure.*

E. ¼, sec. 14, T. 65-3, as of Minn. The hill subsides by steps heastward parallel with the shore. I walked along in search of junction between the Animike and Kewatin formations. The vatin assumes a more distinctly porphyrelloid character (737), much mbling that of Zeta lake. (Rep. 1886, pp. 158-9).

S. E. ¼, sec. 14, T. 65-3, as of Minn. This is very near the critical place. The nearest point on the north shore eastward bears S. 71° E. The strait to the little bay on the south shore bears one or two degrees east of south. On the shore, and for 25 feet above, the Animike clearly outcrops in the form of flinty and red jaspery heavy beds in a *horizontal* position on southward face. Six paces away—18 feet by measurement—the porphyritic sericito-argillytes outcrop standing in the same position as for a mile and a quarter back. The slate here contains abundance of both feldspar and quartz grains.

Beyond all possible question, we have here two formations—even two *systems*. They cannot be identified. What are they? The newer certainly is Canadian Huronian. The older is *not* Laurentian.

The Animike here is contorted-brecciated and conglomeritic. It has a slight dip south.

Rock 738. Porphyrelloid sericito-argillyte, 18 feet.

Rock 739. Flinty, contorted Animike and breccia.

Rock 740. Pebbles from Rock 739.

Walking northeastward along the hill-slope, the fragments of the two formations are found mingled together; but there is an upper limit to the Animike fragments.

The Animike retains an elevation of about ten feet above the lake. The argillitic bluff recedes to a distance of twenty-five feet from the Animike. Huge fragments of the argillyte have tumbled down over the Animike.

Next, at about twenty-five rods east from the last, the argillyte bluff comes quite to the shore again, or within twelve feet of it, for the rugged weathering and brecciated Animike holds the water-line, and appears eight feet back. Here *the two formations are within seven feet of each other*, by measurement. This is virtually a contact.

Next, within two rods more the argillyte comes down to the shore, and completely shuts out the Animike, except in a few fragments washed up from below water level.

The nearest point on the north shore eastward now leans S. 58° E.

The following diagram represents the relations of the two formations at the observed junction:

S. E. ¼, sec. 14, T. 65–3, as of Minn. The argillyte, after receding from the shore a few rods, here reappears.

I was not disappointed to find on the top of the ridge here, a cap of gabbro.

The point is now south 52° east.

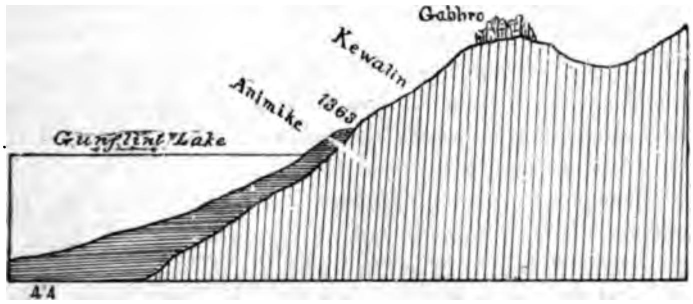


Fig. 44.—*Observed contact of Animike and Kewatin formations, north shore of Gunflint lake, being a section along the line C D of the sketch-map. Fig* 41.

Some Animike fragments lie near the beach within four rods of the argillyte.

N. E. ¼, sec. 14, T. 65-3, as of Minn. The same point bears S. 42° E. The argillyte comes near the shore again. On the beach are large angular fragments of a biotite gneiss (741). As these have not been washed from the southward lying bottom of the lake, they must have come from some short distance northward.

On the hill, the argillyte is very slaty, and the leaves consist of different qualities of rock in alternation.

Rock 742. Interbanded phyllyte.

N. E. ¼, sec. 14, T. 65-3, as of Minn. Hill one-fourth mile back from lake. The point bears S. 31° E. The argillyte is pale gray-blue, but weathers singularly light colored. The plate-structure strikes N. 50° E. The fibrous structure is much disguised by parallel joints. It dips eastward 65°—the joints 55°.

Once again, and for the fifth time I passed along the shore where the Kewatin slate comes in proximity to the Animike. Traced again the shore outcrops of Kewatin quite to the head of Kewatin bay. The rock is considerably altered. Walked again past the spot where gabbro appears above the Kewatin. It is not seen here in actual contact. In some of its conditions the Kewatin slates might be taken for bedded igneous rocks; but the beds are always vertical, and conformable with the other portions of undoubted sedimentary origin. The following further samples were collected:

Rock 785. Kewatin slate, contorted and altered.
Rock 786. Sample of rock which might be regarded eruptive.
Rock 787. Condition undoubtedly sedimentary.
Rock 788. Another sample of sedimentary condition.

S. W. ¼, sec. 13, T. 65-3, as of Minn. Twenty rods north of camp on sec. 13, 65-3. Animike abuts on the shore. It is characteristically flinty and ferruginous, and the sedimentary bedding is unmistakable; but the formation has undergone severe alteration, and breaks up in vertical columns like gabbro. I had to ascend the bluff to be sure that gabbro was not at the top.

On a subsequent occasion this spot was revisited and the following observations made: Some excellent magnetite occurs here. It pertains to a small remnant of gabbro which remains on the north side of the hill, in the position shown below:

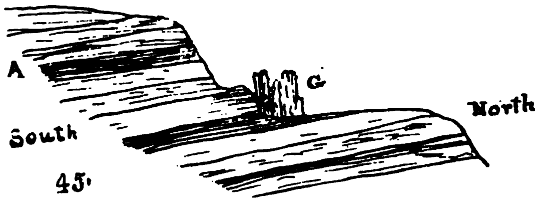


Fig. 45.—*Remnant of gabbro on a knob of Animike slates. Gunflint lake.* Looking westward. A, Animike. G, Gabbro.

It looks as if the whole bluff had been once buried in gabbro and the schist altered, then all the gabbro weathered away except the small lot as indicated on the north side of the ridge. The contact with the schist is sharp; but the schist was already in fragments, and the fluid gabbro flowed around them and into the fissures and converted the schist fragments into quartzose masses. This observation is analogous to that made on an island in lake Gabimichigama, (Report for 1886, page 172).

The slate here has a dip southward of about 15°. Further, we find some contorted fragments; and these facts rather imply that there was in this place more than a quiet overflow. Still as before intimated, the contortion of certain beds may have taken place *during the deposition of the Animike.*

S. W. ¼, sec. 13, T. 65-3, as of Minn. Good camping ground. Animike slates at the point of the promontory south of here (S. W. ¼, S. W. ¼, sec. 13) with gabbro at the summit. Gabbro continues along the ridge northeast and forms a columnar wall in the hill back of the camp. The gabbro appears to be generally intersected by east and west divisional planes, and when the exposure has a westerly aspect, it presents a columnar structure.

S. W. ¼, S. W. ¼, sec. 13, T. 65-3. At the beach, beds of flint schist;

above, gabbro. Here as elsewhere, the schist is horizontal, on a southern aspect.

On a subsequent visit I made the following notes:

The slates here are quite thin laminated, except an occasional bed of flint. The flint beds are curiously variable in thickness, and the upper and under sides do not correspond. This is shown in the following diagram:

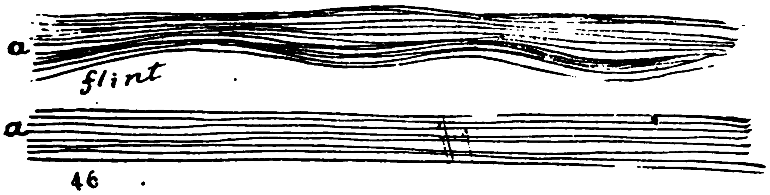


Fig. 46.—*Alternations of flint and flinty shales, Gunflint lake.* a, a, Flinty shales; b, Flint.

I find in this place an abrupt transition from slate to gabbro.

Rock 779 bis. Slate in immediate contact with gabbro.

Rock 780. Gabbro in immediate contact with slate.

Rock 781. Gabbro 1 ft. above slate.

Rock 782. Gabbro 4 ft. above slate.

Rock 783. Gabbro 10 ft. above slate.

Rock 784. Flint from one of the flint beds.

S. E. ¼, S. W. ¼, sec. 13, T. 65-3, as of Minn. At the beach, beds of a granular siliceous rock (688) with a white cement. Above, siliceous argillytes and flint-schists (689) for 20 or 25 feet. Lastly, gabbro (690) mostly of the coarser kind.

Near centre sec 18, T. 65-3, as of Minnesota. At the beach, thick-bedded siliceous magnetite and flint. A little back, fine gabbro eight feet higher.

Rock 683. Black, siliceous magnetitic schist.

Rock 684. Fine gabbro.

It is difficult here, as in many other places, to decide on ocular inspection, where the gabbro ends. Specimens from an intermediate position show blended characters.

Rock 685. Gabbrolitic magnetite.

The rock 685 is about 3 feet above 683. Still below 685, the gabbro 686 rests absolutely on the chert 687 and this on 683; so that the order from above is as follows:

684.
685. } Gabbro.
686.

687. Chert.
683. Siliceous magnetite. } Slate formation.

Just east of this place, we observed a *rusted* rock which when broken open is of a gray color, and which I suspect to be a carbonate of iron.

Rock 813. Carbonate of iron (?) from Animike.

We found other rusted rocks which are black within but do not affect the needle. They are probably anthracitic or carbonaceous. Between the rusty coat and the black interior is a line of gray. It is desirable to ascertain whether the line of gray results from the oxidations of the carbon, and the union of the carbonic acid with the iron; and whether the rusty coat results from a retrograde process—the peroxidation of the iron in the carbonate thus formed.

Rock. 814. Black iron ore with surface bands, from near centre of sec 18, 65–2.

N. E. ¼, N E. ¼, sec. 18, T. 65–2, as of Minn. Extreme east end of Gunflint lake, immediately north of the mouth of Gunflint river. Here is a fine sand beach. The Gunflint river appears sluggish and marshy.

We visited near this spot the camp of a company of Canadian land surveyors in the employ of Sedgwick and Brotherton of Chicago, who had located a large tract of land on the north shore of Gunflint lake and river. The location was supposed to cover valuable deposits of iron ore, and it was desired by us to learn the precise description and visit the principal points in the tract. The parties whom we saw, however professed to be simply camp attendants and to be totally ignorant of the location of any iron deposit. They showed us, however, some samples which were represented to be inferior to the best. The specimens seen were all magnetic ore except one—that was hæmatite. I suspect they were all from the Animike, though they resembled also, ore from the gabbro.

(4) *Excursions from Gunflint lake into the interior.*

(a) *Traverse due north from a point near the centre of the S. W. ¼, sec.* 18, 62-2, *as of Minn.* The starting point was the head of the bay (see fig. 41). A track had been blazed by the surveyors of Sedgwick and Brotherton. Gabbro is found on the shore.

One-third mile north of Gunflint lake. Here occur Animike fragments and soon Animike in place, but not magnetitic argillytes. The rock is highly ferruginous and gives a brown-red streak.

Rock 799. Hæmatite rock.

Rock 812. Conglomeritic iron ore from the Animike, near the last. This rock is in a dislocated condition, and I did not ascertain the dip of the formation; but it appears much like a state of the brecciated Animike which I have before seen many times—always in near relation to the underlying older terrane.

One-half mile north of Gunflint lake. After making a small descent we come to a hill-slope in which we find Kewatin slates outcropping. They are first clean sericitic argillyte. A couple of rods further north we get porphyritic sericitic argillyte weathering much like the porphyritic porodyte of Vermilion lake.

Rock 800. Sericitic argillyte as first encountered, with fine shining scales.

Rock 801. Porphyritic porodyte.

Fifteen rods beyond, the rock is harder and more crystalline, and the shining scales are larger.

Rock 802. Semi-crystalline sericitic schist.

Still beyond, the feldspar weathers reddish, and the rock looks syenitic.

Rock 803. Syenite-looking porphyritic Kewatin schist.

Three-fourths of a mile north of Gunflint lake. A high hill composed of alternating bands of porphyritic porodyte and a rock appearing like true hornblende schist; but the hornblende is still of argillitic softness; and there are fine glistening scales which generally appear like sericite, but in places become large enough to recognize as micaceous. Interbanded with these rock-beds and laminæ are some, mostly thin (up to one-half inch) laminæ of light color, composed of feldspar about 60 per cent, the dark hornblende-like mineral about 30 per cent, and quartz grains 10 per cent.

The rock here is also in places, much contorted. All the characters indicate proximity to some dynamic agency.

Rock 804. Interbanded porphyritic porodyte, syenite and uralitic schist.

There are places where the twisting and interlaminations reproduce the features so often noticed by me last year and figured in my report. For that reason I will not figure them here. I wish to refer particularly to pages 40, 113, 87 and 96. The sinuosities and doublings of the veins are also very striking.

Highest summit of the same ridge. The breadth of the dark bands is increased. The rock is here mostly uralitic schist, but with many bands—mostly not over one or two inches—of the porphyritic porodyte, and many veins of syenite.

Some of the layers of porphyritic porodyte in the uralitic schist are far gone toward the condition of uralitic gneiss.

The belt of uralitic and mixed schist is about 18 rods wide. .This is all there is along this section to represent the Vermilion (or Couchiching) group.

The light and dark bands alternate five hundred times in an exposure three rods wide.

Next ridge, one-eighth mile further north. The rock has the weathered aspect of syenite. Broken, it consists of quartz, white feldspar and uralitic hornblende.

Rock 805. Uralitic syenite gneiss.

At the foot of the next hill, one-fourth mile further north, the formation begins to assume the character of the Saganaga syenite in a gneissic condition.

Summit of range one mile north of Gunflint lake. The rock has become a muscovitic gneiss, with the feldspar and quartz in a compact mass but still granular. See the section fig. 47.

Rock 806. Muscovite gneiss.

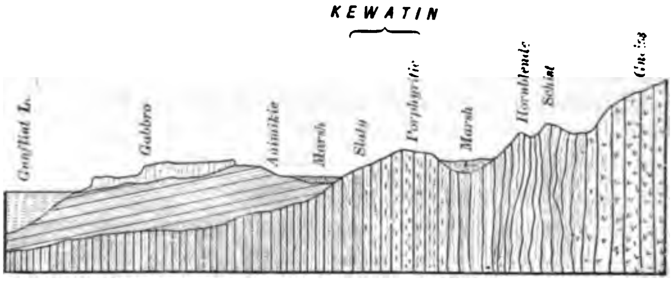


Fig. 47. *Section passed over in one mile on the north side of Gunflint lake near line between ranges Two and Three west; showing junction of Animike and Kewatin systems and transition from Kewatin through crystalline schists to gneiss.* See sketch map, Fig. 41. Vertical dimensions exaggerated, as usual.

This trip shows a gradation from the slates and porphyrel of the Kewatin through interbanded Kewatin and uralitic schist, to well established gneiss—the series of beds being conformable from end to end. The lower (porphyritic) member of the Kewatin has, in its formation, been moulded simultaneously with the uralitic schist, and belongs to the same chronological system. The uralitic schist passes by gradation into gneiss. These three existed and were formed in the same geologic age. The gneiss was *not* subsequently formed. All have been uplifted from a horizontal position simultaneouly.

Rock 807. Illustrating a transition directly from porphyritic porodyte to uraltic gneiss.

Rock 808. Transition from porphyritic porodyte to hydromicaceous gneiss.

Rock 809. Transition to mica schist.

Rock 810. From a dyke crossing the formation a little east of north and west of south.

Rock 811. Augitic? band in the uralitic schist.

It is to be especially noticed that the mode of transition from Kewatin slate to uralitic schist is different from the transition from Kewatin to gneiss. In the former case, the Kewatin becomes intersected by conformable laminæ of the uralitic schist; then thicker laminæ with thinner bands of Kewatin; but every lamina is all the time complete schist, as a rule. In the latter case, the porphyritic condition of the Kewatin begins to reveal pale dark or dun areas of limited extent; then these acquire a uralitic aspect; then farther on, a hornblendic aspect. Meantime, also, quartz, which is generally present to some extent, in the porphyry, becomes more abundant. We then have the constituents of syenitic gneiss (hornblende granite). Sometimes the dun and dark substance which arises in the porphyrel passes to mica instead of uralite and hornblende, and we get a pure gneiss.

(b) *Mr. Stacy's Traverse north from N. E.* ¼, *sec.* 22, 65–3, *as of Minn.*

On no one of my five or six visits to the place of first discovery of Kewatin slates on the north shore of Gunflint lake was it convenient for me to penetrate the interior further than a quarter of a mile. I was therefore desirous that Mr. Stacy should go over the interval between the shore and the crystalline rocks which I felt sure must exist in the higher range about three-fourths of a mile back from the shore. Mr. Stacy's detail of observations will be given from his own notes in the proper place; but I wish here, for the sake of completeness in my description of Gunflint lake geology, to record the result. After passing the valley intervening between the ridge in S. E. ¼, sec. 15, 65–3, and the higher range, the Kewatin began to be found interstratified with layers more or less inclining to a micaceous state. But before the mica schist was found completely developed, gabbro was encountered resting on the crest of the hill. It was a thin bed, but coarse in quality.

(c) *Mr. Stacy's Traverse north between secs.* 13 *and* 14, 65–3, *as of Minnesota, north shore of Gunflint lake.*

This traverse was about one mile in length. Kewatin continues for about three-fourths of a mile, when the usual transition to micaceous strata occurs. At a mile from the lake, gneiss is fully established. Syenite characteristically constituted occurs on the highest summit reached. The belt of crystalline schists is about a quarter of a mile.

These three traverses are separated by intervals of about a mile. The geological developments are in their general features identical in all. There is a transition of the same nature in all, from Kewatin slates to crystalline schists, and an identical passage from these into conformable gneissic beds.

(d) *Visit to the Iron deposits in sec.* 23, *T.* 65-4, *west of Gunflint lake.*

These deposits are embraced in the tract located under the personal direction of Mr. Buddle who stated that he was in the employ of Milwaukee parties. Reference is made to it on pages 80 and 247. It seemed eminently desirable to ascertain the geological situation of the iron, and a trip was accordingly made by my brother and myself.

The trail to the location lies along the north line of section 24, T. 65–4. Its position is at the foot of the Giant's Range. It passes over a surface apparently underlaid by Animike slates, but the syenitic bosses rise close by on the north and in places present precipitous exposures. The surface over which the trail passes is hilly, and presents a gradual ascent toward the interior.

After reaching the northwest corner of sec 23, a branch of the trail turns southward along the west line of the section. Going south about a quarter of a mile an exposure is seen, of which the following is a section from north to south.

S. W. ¼, N. W. ¼, sec. 23, T. 65–4. Outcrop of magnetitic beds of the Animike.

The iron (829) is about six feet thick, and the two lower members aggregate about eight feet. The dip southward is about 10°. On the north is low ground, and many syenite bowlders.

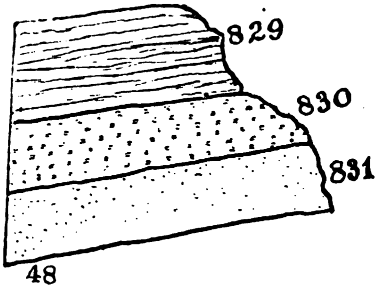


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Fig. 48.—*Outcrop of magnetitic beds of the Animike.* 829, Beds of magnetic iron ore. 830, Quartzose "muscovado." 831, Bluish compact rock not determined.

Rock 829. Magnetite at surface.
Rock 830. Quartzose muscovado.
Rock 831. Bluish muscovado-like, but undetermined.
S. E. ¼, N. E. ¼, sec. 22, T. 65–4. About ten rods further west.

Here is an opening in the form of a shaft for exploration. It passes hrough the whole of the magnetitic beds and terminates on syenite gneiss (833). The magnetite (832) here is from three to four feet thick, but varies in quality both horizontally and vertically. Some of it is quite superior in richness. From first quality it passes down to the ordinary magnetitic Animike. It is here quite massive. The exposed surfaces are black. It is cut by joints somewhat rectangularly. It is powerfully magnetic as a mass, and in hand specimens. At the bottom of the bedded ore is a zone considerably broken and confused. It is also rather cherty.

At the plane of contact between the Animike and the gneiss is a layer of brown earthy matter (834), about four to six inches thick. In places there appears to be a sheet of Animike rusted and decayed. But the greater part of this bed plainly comes from the decay of the gneiss, for it abounds in gravel which apparently represents the quartz of the gneiss. This decay I scarcely think a result accomplished since the deposition of the Animike; for the Animike would protect the gneiss as effectually as so much superincumbent gneiss. This layer then, is an ancient soil which was formed during ages of aerial or submarine exposure, before the Animike had existed. It would not extend under the Kewatin, because there is no definite bottom to it. Its history is continuous with that of the gneiss. This soil would extend underneath the Animike and above the Kewatin.

It is noticeable also, that the "muscovado" beds are not present.

This shows that the border line of the Animike sediments moved northward during the Animike age—whether from filling of the sea, or from a moderate subsidence northward. The gneiss therefore, existed as it is before the Animike, and is certainly not later in appearance as a formation. A slight subsequent elevation of the gneissic region may have given the Animike its slight inclination.

In the following diagram, the facts are shown, as above stated, together with the supposed relation of the Kewatin to the other formations.

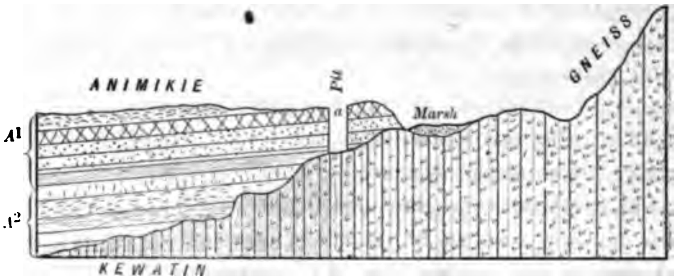

Fig. 49.—*Geological positions of the Magnetite stratum two miles west of Gunflint lake.*

Shows junction of Animike and gneiss and the supposed unconformable subterposition of the Kewatin.

G, Vertically schistose gneiss. K, Vertical Kewatin (not seen here). A1, Nearly horizontal Animike, upper beds, A2, Animike, lower beds of the vicinity (not exposed here).

a, The principal iron ore beds. *e*, Layer of gravelly earth.

(5) *Reflections on the geology of Gunflint lake and vicinity.*

The following inferences from observations made about Gunflint lake were penned on the spot, while in the presence, and under the influence, of the phenomena of which some account is given in the preceding pages. These fresh impressions may possess a value in some respects superior to that of deliberate conclusions penned after the vividness of the impressions has worn off.

It would appear that this entire region has been covered by an outflow or overflow of gabbro in a fluid state. The erosions of later times have removed a large part of it, and eaten down many feet into the slates. The slates generally are more destructible than the gabbro; and where exposed, wastage has been more rapid than on the gabbro-covered areas. Hence it is, as I suppose, that the gabbro remaining has been left crowning the summits of the hills of relief. It is not to be supposed that the gabbro was erupted along these ranges. There may have been great fissures located somewhere, through which the gabbro escaped, and from which it flowed over hundreds, perhaps thousands of square miles.

The gabbro is everywhere in visible progress of degradation. Long, massive flakes become detached and fall down—often rolling to the base of the talus. Other flakes are seen to be disengaged, waiting for a few seasons more of the leverage of expanding ice to throw them over. Meantime the shales below vanish by a process less grandiose. The work is so slow that a given surface remains relatively permanent, and vegetation takes root on it. Even trees have time to grow, while their foundation disappears beneath them. But not only herbs and shrubs, but sturdy trees yield when the time arrives for the destructive blows of the descending gabbro, or the silent undermining of atmospheric disintegration and decomposition. Though these results are coming to attainment even while we gaze on the spectacle, if we look around and contemplate the vastness of the work already accomplished, we are bewildered in the attempt to grasp the æons of time which have elapsed since the configuration of hill and valley and lake basin, as we now look upon them, has been slowly attaining its present features.

Note.—The only considerable record hitherto published of facts observed about Gunflint lake are contained in the *Ninth Annual Report*, Geology of Minnesota, 1880, pp. 81-83, and the *Tenth Annual Report*, 1881, pp. 86-88. Incidentally the geology of Gunflint lake is referred to in the *Seventh Annual Report*, 1878, pp. 11 and 21. These accounts are by professor N H. Winchell, the state geologist. Mr. Robert Bell, of the Canadian Geological Survey, who passed along the boundary in 1872, has given ten lines to Gunflint lake in the *Report of Progress* for 1872-3, pp. 92-93. Dr. J. G. Norwood in his flying trip along the boundary in 1849, made a few observations on Flint lake which may be found in D. D. Owen's *Report of a Geological Survey of Wisconsin, Iowa and Minnesota*, Philadelphia, 1852, pp. 416 and 417. No details of facts have yet been published by the United States Geological Survey, but professor R. D. Irving who has in charge the investigation of the Archæan geology of the Northwest, has made, as is understood, in person and through assistants, extended observations about Gunflint lake. Some of professor Irving's interpretations of the observations have been published in the *Third* and *Fifth Annual Reports* of the U. S. Geological Survey as already cited on page 144 and in the *American Journal of Science* III. Volume xxxiv. The present writer has described the unconformities of the Animike in *Amer. Jour. Sci.* Oct. 1887, and the *American Geologist*, Jan. 1888, pp. 14-24.

§ 13.—NORTH LAKE.

This is also known as Mountain lake; but I employ designations found on the government plats. It lies on the boundary in the form of an isosceles triangle having the axis lying in a position east-northeast and projecting into Canadian territory, while the base abuts against the United States. Accordingly, the American shore embraces only the base and one side of an irregular bay projecting westward from the northern angle, and both sides of a similar bay projecting southwestward from the southern angle at the base. It lies in township 65–2 W., and covers an area about two-thirds as large as Gunflint lake. Its altitude above lake Superior barometrically ascertained by professor N. H. Winchell is 1057 feet. On the south a ridge trending nearly east and west and about 100 feet high, separates it from South lake; and on the north lies the continuation of the Giant's Range, rising to an altitude exceeding a hundred feet. The north shore is deeply indented by bays and capes. A large part of the forest contiguous to the lake has escaped burning. A portage leads northward from the Canadian shores toward Northern Light lake and a region of considerable exploitation for iron. The boundary portage goes out from the south side of the lake in section 22, while the Gunflint river furnishes connection with Gunflint lake.

This broad stream out of North lake is somewhat choked by Juncaceæ. *Nymphæa odorata* remains in bloom to the end of August.

N. W. ¼, S. E. ¼, sec. 17, T. 65–2. North shore of Gunflint river. A low outcrop of syenitic gneiss—779.

The Gunflint river flows along the junction of the gneiss and the Animike formation. No rock exposure on the south shore as far as the rapids.

N. E. ¼, S. E. ¼, sec. 17, T. 65–2. Rapids of Gunflint river. The descent here is about four feet but our canoes were pulled up. The amount of water is small, as North lake is the source of the boundary river—of which Gunflint river is a local name. Here are many angular fragments of a dark rock graywackenitic looking; but a second visit disclosed flint schist in place on the south side

S. W. ¼, N. W. ¼, sec. 16, T. 65–2, as of Minn. At the widening of Gunflint river. Syenite gneiss (744) comes down to the north shore, containing abundance of well-defined black hornblende and white feldspar with a glassy quartz.

N. E. ¼, N. E. ¼, sec. 16, T. 65–2. South side of bay near entrance to the lake. Stratified beds of flint having a southeasterly dip of about 8°.

N. E. ¼, N. E ¼, sec. 16, T. 65-2. Extremity of point. Massive dark granular rock (745) with much magnetite and disseminated specks of red feldspar. This rock is like some seen where we first enter Animike bay from the north.

S. E. ¼, N. E. ¼, sec 16, T. 65-2. South side of point. Rock much like the last. There appears to be a red-weathering feldspathic constituent—in places white or yellowish weathering; also a dark greenish mineral forming a sort of groundmass for the delicate plates of glassy feldspar seen on fresh fracture. There are rude indications of horizontal bedding.

Rock 746. Diabasic? rock.

S. W. ¼, N. E. ¼, sec. 16, T. 65-2. A low outcrop of gabbro (747) of finer than medium texture.

S. W. ¼, S. E. ¼, sec, 16, T. 65-2. South side of second point. A low outcrop of gabbro of character like the last.

Further toward the southwest on the shore no outcrops were found. The south shore, from the western extremity to the portage is also without exposures.

On a second visit to North lake I made a visit with my brother to the north shore at departure of the trail to Northern Light lake. This is at the head of the bay in N. E. ¼, S. W. ¼, sec. 10, as of Minnesota. A quarter of a mile from the shore a hill rises on the right 75 to 100 feet high and at its foot (on the west) are formed fragments of flint schist and magnetitic schist. These had apparently descended from the hill; but we saw no Animike rocks in place. We found gabbro in place, however, down at the level of the trail.

N. E. ¼, N. W. ¼, sec. 10, T. 65-2, as of Minn. North shore of North lake on trail to Northern Light lake, about half a mile from North lake. Here we found gneiss (778) in place, with black mica and much glassy feldspar with some opaque feldspar.

Some examination was made beyond this point but without observing any change in the geology. Obviously, we find here the foot of the Giant's Range, with hills of gabbro-crowned Animike close following on the south. The situation corresponds geologically with that of Black Fly bay at the west end of Gunflint lake.

Dr. Norwood has the following observations on North lake:

" On the long point which projects into Mountain (North) lake, near the termination of the portage (from South lake, as understood) the rock is schistose. and alternates with thin flinty layers. About a mile below this point, on the north side of the lake, is a low exposure of granite, which slopes down to the margin of the lake. It is in low bosses, from ten to thirty feet in hight, which are bare, or only covered with mosses and lichens. Back of this is a high ridge, bearing east and west, which ascends by a series of steps or plateaus, covered principally with mountain ash and small maple. About one-fourth the hight of the ridge is a granite exposure *in which masses of hornblende rock were found completely enveloped.* Still higher up, where the hornblende rock is traversed by small granitic veins, it becomes somewhat altered in character, and resembles diallage rock. The top of the ridge is composed of coarsely crystalline hornblende. This exposure, like the one on the dividing ridge (between North and South (?) lakes) shows clearly the evidence of having been subjected to igneous action since its upheaval I think it highly probable that it had a schistose structure prior to the eruption of the granite. On the top, many large, weather-worn fragments of granite occur, but no vein of that rock was seen."*

The statements made above in reference to the "hornblende rock" are not consistent with my present knowledge of the region.†

§ 14.—SOUTH LAKE.

South lake, the next eastward along the boundary lies mostly in Town 65–2, west, and its environment is physiographically similar to that of North lake. A range of hills from 50 to 150 and 200 feet in altitude skirts the south shore; but there are few rock exposures along that shore. On the north the features are similar, but with frequent low outcrops. The north shore remains largely in the possession of green timber of the original growth. Much growing birch and some poplar occupy the lakeward slopes of the south side; but they are young trees dating from the last general burning.

The general geology of both shores is Animike, consisting chiefly of thin-bedded black slates; but these are capped extensively, especially along the north shore, by sheets of gabbro.

The elevation of South lake, as barometrically ascertained by N. H. Winchell, is 1,057 feet above lake Superior. This is exactly the same as found for North lake, and indicates that perhaps a slack water communication exists between the two. Yet the known topography does not favor such a connection; and the fact that South lake is drained into lake Superior, and North lake into Hudson's bay would imply that the identical elevations are simply a coincidence without special cause.

The portage from North to South lake lies chiefly in N. W. ¼, sec. 22, T. 65–2 W. It passes southeasterly over a depression in the ridge lying off the south shore and is about a quarter of a mile in length.

S E. ¼, N. W. ¼, sec. 22, T. 65-2. About half way over the portage. A low ledge of gabbro (748) extends along the east side of the portage. It contains in places much magnetite.

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* Norwood in Owen's Geological Survey of Wis., Iowa and Minn.

† See reference to same region in Ninth Ann. Rep. Minn. pp. 80-81. The "hornblende rock" locality of Norwood is very likely the same as that at which N. H. Winchell obtained his rock No. 305.

Reaching the north shore of South lake, only about a mile of that shore belongs to the United States. The course of the survey is first westward along the north shore to the western extremity and thence eastward along the south shore. The north shore is mostly covered by gabbro.

S. W. ¼, S. W ¼, sec. 22, T. 65-2. Here are low-lying, thick beds of magnetitic Animike,—749.

S W. ¼, S. W. ¼, sec. 22, T. 65-2. A crumbling bluff of gabbro of medium texture. A gabbro cliff, sometimes degraded to a crumbling slope, extends along this north shore.

No exposures of rock in place occur along the south shore of South lake. The shore is lined with rounded bowlders mostly syenitic. Just after passing the inflow of the little stream in sec. 24, a hill rises on the south, on the slope of which crumbling gabbro is seen; but no rock appears in place along the entire south shore.

On a later occasion I coasted along the entire northern shore of South lake.

N. W. ¼, sec. 24, T. 65-2, as of Minnesota. Projecting cape about midway of the north shore. Outcrop of compact, medium-grained heavy gabbro,—777.

I observed gabbro at ten localities along the Canadian shore of South lake. They are mostly exposures near water-level, or not over ten or fifteen feet above.

Dr. Norwood has recorded remarks on the geology of the shores of South lake (which he calls Ashawiwisigaton) which are quite unintelligible to me. Proceeding from the eastward he says: "The twelfth portage is four hundred and forty paces in length, and leads over a low ridge, with numerous bowlders of syenite, gneiss and granite, scattered over it to Ashawiwisigaton lake. The ridge is composed of a syenitic rock underlying hornblendic slates at the west end. On the shores of Ashawiwisigaton lake, there are constant exposures of metamorphic slates in low ledges, rising only a few feet above the water level. The last high mural precipice seen along the boundary line (traveling westward) was near the lower end of this lake. On the *American* side, is a ridge of syenite four hundred feet in hight, with a rounded outline and rather gentle slopes." (Of this he gives a figure.)

This statement is unaccountable to me, since I find Animike slates and gabbro along the north shore, and the same slates, at least at one point, within sight on the south shore.

But he further says: "The thirteenth portage is 540 paces long, and leads over the dividing ridge between the tributaries of lake Superior and those of Hudson's bay to Mountain (North) lake. The rock forming the summit of the ridge is *syenite*, associated with massive hornblende. (This does not appear on the portage nor on the summit. On the contrary, gabbro appears along the portage). On the long point which projects into Mountain (North) lake, near the termination of the portage, the rock is schistose, and alternates with flinty layers."*

§ 15.—RAT LAKE.

This is a very small lake not deserving of mention except in a complete enumeration. It is reached by portages both from the west and the east. It is about half a mile long from north to south, and a quarter of a mile wide from east to west. The portage to it from the west is at least a quarter of a mile long—three times the length shown on the plat. The little stream destined to become Pigeon river flows on the north of the trail. Rat lake is mostly filled with reeds and rushes.

S. E. ¼, N. E. ¼, sec. 19, T. 65-1, as of Minn. East side of Rat lake near portage eastward: A small hill having on the slope gray slates in horizontal outcrop, and at the summit a fine, iron-gray rock with vertical jointage like gabbro, and no horizontal bedding. It is the same kind of rock as I styled fine noryte in Animike bay, and I will so style it here.

Rock 750. Gray Animike slate.
Rock 751. Fine noryte resting on the slate.

§ 16.—ROSE LAKE.

Rose lake, also called Mud lake, is a slender serpentine body of water lying on the national boundary in Town 65-1 west. Its width along the western half is not over a quarter of a mile. In the middle is a deep broad bay setting southward, and the eastern half has a mean width of about two-thirds of a mile. Four deep broad capes indent the shore-line on the north. High Animike hills, gabbro-crowned overlook the lake from the south from altitudes of 125 to 300 feet. The immediate shore is fringed with a dense forest of young birches along the western half, while old Norway pines and spruces replace them along the eastern half. The country along the north shore is but little elevated, and is largely covered with original forest, the birch and poplar being most conspicuous toward the western end. Within a mile of the eastern extremity the Arrow river goes out from the north shore toward Arrow lake three-fourths of a mile distant. Nearly opposite the exit of this stream, Pigeon river goes out on the south side, but eastward toward Rove lake. The lake is reported 1,022 feet above lake Superior.

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* On this ridge and adjacent geology, see also *Ninth Ann Rep Minn. Surv* 1880, p 80-81.

Actual outcrops of rock along the shore lines are few; but such as occur reveal the uniform presence of the black nearly horizontal Animike slates overlaid by gabbro.

N. E. ¼, S. E. ¼, sec. 19, T. 65-1. End of portage from Rat lake. Low outcrop of gabbro (752), fine and abounding in magnetite.

Rose lake mountain to the south of this locality rises with a parabolic sweep from the shore to the vertical gabbro wall which rests on its summit. It stands a quarter of a mile back from the western part of the lake. It rises fully 200 feet, and from its isolation it seems very conspicuous. The gabbro structure is distinctly basaltic. I took a photograph from the nearest point opposite, but the distance was rather too great.

Rose lake is shallow and much grown with rushes. An extraordinary amount of white birch grows on the south shore; but as the land rises these give way to spruces, which alone hold possession of the high ridges.

S. E. ¼, N. E. ¼, sec. 20, T. 65-1. The gabbro (753) comes down to the shore, and that at a point only about three-fourths of a mile distant from the summit where it stands 150 feet high. It is not likely, however, this difference in altitude indicates the original thickness; for the Animike must have been much eroded before the gabbro was erupted.

N. W. ¼, N. W. ¼, sec. 21, T. 65-1, as of Minn. Gabbro, with lumps of waxy feldspar, up to one and a half inches in diameter. This is like gabbro seen on Animike bay and in many other places.

S. E. ¼, S. W. ¼, sec. 22, T. 65-1. A beetling bluff of columnar gabbro (754) at entrance to the bay protruding southward toward Duncan's lake. At base, near the water, it is fine and graywackenitic-looking, but contains fine prisms of glassy feldspar. On the opposite side of the bay is a gabbro-crested hill 150 feet high.

N. E. ¼, N. W. ¼, sec. 27, T. 65-1. Stair portage to Duncan's lake. A smart stream comes roaring down in a cataract of at least sixty feet. The portage is much worn. It ascends by a series of steps cut in the earth and rocks. This is a frequented route to Birch lake, Daniel's lake and the whole region southward. Gabbro is the formation passed over here, and gabbro reveals itself on all hands, in decaying cliffs and rubbish-strewn slopes.

Dr. Norwood calls this stream the Wisacodé river. He says the portage over is about a thousand yards long, and crosses a ridge over three hundred feet in hight.

S. E. ¼, S. E. ¼, sec. 22, T. 65-1. Animike slates (755) outcrop in the usual horizontal position. They are here a heavy black thin bedded argillyte.

From mouth of Stair Portage bay one sees on the Canadian side, an enormous gabbro bluff facing westward. I estimate it as 75 feet perpendicular.

There are no more exposures eastward as far as the portage. This does not go out at the stream as indicated on the plat; but over a quarter of a mile beyond.

N. E. ¼, N. E. ¼, sec. 24, T. 65-1. On the portage from Rose lake to Rove lake, one-third of mile from the latter. Magnetitic and brecciated Animike—rock 756.

This is the variety which seems to stand vertical. I looked carefully for the Knife lake slates, but the formation was always gabbroloid—not well formed gabbro.

This portage proves to be about a mile and a half long, by the windings. It is comparatively little frequented. It is hilly and stony and overgrown. It is to be avoided as much as possible. I have a suspicion that the usual route is south of the boundary, by Duncan's, Birch and Daniel's lakes.

I looked for signs of Animike slates all the way, but only saw quite numerous fragments of black slate, about a third of a mile from Rove lake

§ 17.—ROVE LAKE.

Rove lake lies in sections 19, 20, 21, 22, 15 and 16 of Township 65-1E. having a length of about four miles, with a mean width of half a mile or less. It consists of two parts connected by a narrow neck of slack water. The eastern part is called Watab lake by Dr. Norwood, and the western part is spoken of simply as "several small ponds connected by a narrow stream." The eastern part is arcuate in form and lies with its mean axis precisely northeast. The western part which is a genuine lake, with a wide constriction near the eastern end, lies in a direction east southeast. Near the western end of the eastern part is a deep constriction narrowing the lake to fifty feet. The land on the north is a point projecting northeastward, with a little bay behind it. The point is about eight rods wide, and the bay about twelve. The point I named Camp Reunion. Almost directly opposite rises the loftiest slate and gabbro hill thus far seen. This I named Mount Reunion. In entering the lake from the narrows this hill is a very conspicuous and impressive feature. It appears as if a mountain had been cleft asunder by a vertical blow and one-half completely removed. Photographic views were taken of this, but they will not appear in the annual report. At the summit is a vertical cliff of gabbro rudely columnar estimated at 80 feet in hight. This faces southwest, west and north. Beneath this vast wall is a precipice of slate whose horizontal stratification is apparent from Camp Reunion. The tendency to columnar features extends down thirty feet into the slate. This portion of the mountain presents also a vertical face, and is estimated at 80 feet. Below this lies a talus of dark angular fragments sloping at an angle of 45° toward the lake. The upper portion of this is naked for an altitude of fifty feet. The lower portion of the slope becomes less steep, and is concealed and partly covered by a dense growth of young poplars (*Populus tremuloides*). The vertical altitude of this part of the talus is about 75 feet. Mount Reunion therefore is estimated to have an elevation of 286 feet above Rove lake. Dr. Norwood puts it at "over 300 feet," and this may be more accurate.

Mount Reunion is the first of a succession of lofty hills ranged along the south side of Rove lake, each of which is vertically chiseled off on the lakeward aspect, and all of which run together at their bases into one continuous range. Their altitudes reach well toward three hundred feet. Still, outcrops along the water-line are few; and the lower flanks of the range are covered with a belt of handsome green poplars, grown since the last general burning. The north shore is depressed, and rocky outcrops are there also of rare occurrence. The point called Camp Reunion is a mass of angular, hard ringing fragments of a dark, cryptocrystalline rock having a very eruptive aspect.

At the west end of Rove lake are three abandoned log cabins. They appear to contain merely a few articles used in a winter camp, and are reported as belonging to the Mayhews at Grand Marais. On the north a road had been at some time cut out. Southward a cut-out road or portage extends to Daniel's lake and thence to Grand Marais.

N. E. ¼, S. E. ¼, sec. 20, T. 65-1E., as of Minn. Camp Reunion. This point is an old pile of gabbro all gone to fragments. There is very little soil, and that is mingled with the ashes of a former burning. The point is now all densely overgrown with young poplars, birches, pines and alders. The fragments are all quite angular. The point seems a mere pile of them 10 or 12 feet high. A few rounded syenite bowlders are intermingled.

N. E. ¼, N. W. ¼, sec. 21, T. 65-1E., as of Minn A low outcrop of rock with dark weathered surface like iron (757), and when broken, still looks in color and texture like fine iron—darker than steel. It is also very heavy. It belongs to that formation so often seen outcropping similarly, and always resembling iron. This, as in other cases, is considerably below the level at which Animike is seen on the mountain side. If the iron bed belongs in the Animike as I have heretofore been led to believe, its position here must be at least 200 feet below the summit of the formation, or there must be a fault between this point and the mountain along the south shore. But I have supposed the Animike iron bed to belong near the top of the formation; and if this is altered Animike there certainly is a fault along the axis of Rove lake. If, on the contrary, this iron bed belongs in the gabbro, which for the present seems likely, it is not the equivalent of the bed seen about the west end of Gunflint lake but of the deposits subsequently seen about Iron lake. This being assumed, it becomes evident that the overflow of gabbro covered a country already deeply eroded—a surface already very ancient. Hence, when later erosion carried away the gabbro along the slope (as at A, fig. 50 the slate became exposed, and gabbro remained both at the higher level and a lower.

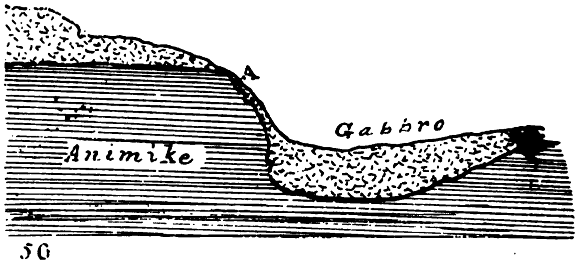

Fig. 50.—*Eroded surface receiving a flow of gabbro.*

N. E. ¼, N. W. ¼, sec. 22, T. 65-1E. A rod back from the shore and concealed by bushes is a wall of vertically jointed compact rock, composed of a dark base and uniformly distributed specks of red feldspar. This is the same as often seen heretofore.

Rock 758. Fine noryte?

N. W. ¼, N. E. ¼, sec. 22, T. 65-1E. This is only half a mile from the last. Outcrop of decaying, rusty black, horizontally lying Animike slates (759), with fine noryte above, in clear contact. The noryte is exactly like that last mentioned.

The little used portage from Rove lake to Mountain lake is about a third of a mile long.

N. W. ¼, N. W. ¼, sec. 23, T. 65-1E. On the portage. Noryte outcrops in angular-splitting masses at frequent intervals along the portage.

§ 18.—MOUNTAIN LAKE.

This lake is six and a half miles in length, lying on the boundary in Towns 65-1 and 2 east, and with an average breadth of about half a mile. The south, or Minnesota shore is little indented; but the north shore presents two deep bays penetrating half a mile inland, and several land indentations. Off the south shore is a continuation of the high range described under Rove lake, and it is similarly broken into a succession of imposing, gabbro-capped hills, with parallel-bedded dark schists underlying and fragmental taluses stretching toward the lake. Several of these hills reach an altitude of 250 to 300 feet above the lake; and farther back are summits said to be feet 375 high—being 1,527 feet above lake Superior and 2,129 feet above sea-level. The north shore is not elevated and the surface comes down generally to the lake-level. This is specially true of the western part. Farther in the back ground, however, hills are seen rising apparently, in one instance, as much as 200 feet above the lake. Notwithstanding the rocky character of the region on the south, the outcrops are few. The talus appears generally to have reached the water-line. On the north shore, however, which I meandered watchfully, I recorded, besides the stops which will be described, twenty-two low outcrops of gabbro.

The vertical gabbro crests along the south shore appear to be generally 50 to 75 feet high; and the vertical slate cliffs next below are of about the same hight. The line of junction between the gabbro and the slate can be seen distinctly from the lake; and the horizontal position of the slates is very obvious. The vertical hight of the talus of the principal summits is about 75 feet.

The original forest of the south shore has been destroyed by burning. The only trees living are a new growth of poplars fringing the beach. Burnings have not reached the north shore except toward the eastern end. In the middle portion of the north shore, a heavy green forest stretches into the interior. In the western part are dense forests of poplar and birch, which appear to be a second growth.

Meander corner between secs. 19 and 30, T. 65-2E. The fragments found here—for no exposure occurs between the western end and this point—consist of crumbling argillyte of dark color, and of gabbro. Some of the gabbro is very coarse, and also crumbling. Both rocks are much peroxidized.

The shore is exceedingly monotonous. Between the water-line and the talus is a slope of about fifteen degrees uniformly covered with a dense growth of young poplars. The soil on which they grow consists mostly of angular fragments of gabbro and crumbling sheets of dark argillyte. Above this green, wooded slope comes the talus, consisting of large fragments of the same sort, on which there is no soil, or safety for tree growth. Over this, fragments large and small, are occasionally precipitated to be hurried down the talus slope of about 45°. This work must be more rapid in winter and spring. Evidently the mass of the talus is augmenting, its vertical hight increasing, and that of the precipice diminishing. Evidently, also, the precipitous face will eventually become covered by the growing talus, and evidently, since this work is not already accomplished, the present course of change has been in progress but a limited period.

N. W. ¼, N. E. ¼, sec. 21, T. 65-2E. Nearly opposite the eastern constriction of Mountain lake. Here, a rod back from shore, is a slope of 45°, composed of angular fragments. The rock is a darker variety of noryte (*760*), than I have seen before. It is also exceedingly fine, and heavier than usual. I would call it diabase, except that its association with gabbro perhaps indicates the presence of a basic plagioclase.

Near the east end of the lake, the gabbro range is lower, and the crowning cliff has already become concealed or nearly so, by the rising talus, which here slopes almost to the water's edge. But at the end are two bluffs with high precipices remaining. These appear to have been originally higher than the last mentioned.

In the hill at the end of the lake the slates can be seen beneath the precipice of gabbro.

On the return I meandered the entire northern shore of Mountain lake. Along the whole shore the only rock in place is gabbro. It occurs mostly in low bluffs at the water's edge—some of it in heavy, nearly horizontal beds. But there are some cliffs close on shore with an elevation of 15 to 20 feet. The exposures are decidedly frequent.

I landed at twenty-four points—all of gabbro. Yet there are considerable stretches without outcrops.

N. W. ¼, S. E. ¼, sec. 14, T. 65-2E. Portage out of Mountain lake eastward. On the Canadian side of the stream, on which the portage lies, I ascended the hill to the summit, and found it formed of coarse crumbling gabbro. The gabbro makes here, as everywhere, a coarse brown soil colored by iron peroxide.

This is the hill on which I discovered the unusual species of blueberry mentioned in the introduction. Here also I observed the shadfrog mentioned.

This portage eastward out of Mountain lake, also little traveled, is about a third of a mile long, and joins the Pigeon river below the rapids. The river soon widens, and is so filled with scouring rushes as to be nearly impassable. This swell is known as "Upper Lily lake."

After a quarter of a mile of boatable water, another much neglected portage of a quarter of a mile occurs, on the Canadian side of the rapids, leading to another small swell in the river which is sometimes denominated "Lower Lily lake." This continues for a quarter of a mile, when other rapids occur, and we enter on the portage which terminates on Moose lake. This portage lies also on the north side of the river, and is about two-thirds of a mile in length. A range of gabbro continues along the south side thus far, but it is less than a hundred feet in hight. The portage is bad.

S. W. ¼, S. E. ¼, sec. 13, T. 65-2E. American side, near entrance to portage from Lower Lily lake to Moose lake. Coarse gabbro (761) with a large percentage of iron.

Similar gabbro occurs at the portage on the Canadian side.

N. E. ¼, N. E. ¼, sec. 24, T. 65-2 E. On the same portage, one-eighth mile from Moose lake. On the Canadian side, a knob of Animike breccia outcrops from the hill slope.

On the American side of Pigeon river, a range of gabbro overhangs the stream, all the way to Moose lake.

§ 19.—MOOSE LAKE.

Moose lake lies in the western half of Township 65-3 east. Its longer axis stretches east southeast and is three and a half miles long. The lake has a mean width of a mile. The contiguous country presents an aspect not materially different from that surrounding Mountain and Rove lakes. The gabbro-crested hills on the south attain elevations as great; and the north shore is similarly depressed. A mile back, however, on the Canadian side, reveals toward the northeast two strikingly elevated summits, but perhaps not over three hundred feet.

The country on the south side is mostly burnt over; but near the shore is frequently stocked with young poplars. On the north side Norway pines abound on the west and also on the east, but considerable burnt country intervenes.

There are few outcrops on the shore-line of the south side. I noted gabbro at seven points in low outcrops, along the Canadian side

After examining the south shore for the distance of a mile and a half, from the west end, and finding no rocks in place, I ascended the hill about eighty feet and discovered a ledge of slate. There is no gabbro visible from this point, but it can be seen from the opposite shore at a higher altitude, resting on horizontal slate.

S. E. ¼, S. W. ¼, sec. 20, T. 65 3E. The slate is much shattered, and the talus slope is mostly overgrown with small cherry bushes. Most of the slate is in layers from half an inch to an inch thick; some in beds of several inches and quite solid. The solid beds are dark, fine-grained, heavy, identical with the fine rock which I have often seen, always feeling doubtful about its relations to erupted material. Here it is distinctly embraced in beds of sedimentary character. If eruptive, they can only be intrusive. The thinner layers, however, are similar in color, texture and weight. Occasionally, is a layer of darker color, evidently from the abundance of magnetite.

Rock 762. Three varieties of Animike.

Farther east, this same cliff is completely covered by the talus slope, but so recently that no soil has yet accumulated for the growth of shrubs, except in patches

Still farther east, the ledge reappears, and the uncovered talus slope is about two rods wide. The slate ridge gradually approaches the shore Here is an other occurrence of gabbro. This is in the N. W. ¼, N. E. ¼, sec. 28, T. 65-3E. Gabbro is again seen, a quarter of a mile east, on another hill not over 50 feet in hight.

S. E ¼, S. E. ¼, sec. 21, T. 65-3E. Half mile from foot of Moose lake. Outcrop of horizontally bedded slate. The beds are two to four inches thick, and of similar character to that last described.

S. E. ¼, S. W. ¼, sec. 22, T. 65-3E. At portage east out of Moose lake. Gabbro on Canadian side, coarse, altered by weathering, as usual, with much magnetite—763

Rock 764. Animike from shore fragment—apparently almost pure magnetite.

N. W. ¼, S. E. ¼, sec. 18, T. 65-3E., as of Minn. North shore of Moose lake. A low outcrop of probably gabbro, of dark gray color, and scattered slender crystals of glassy feldspar. I have seen the sort before.

Rock 776. Peculiar gabbro. North shore of Moose lake.

I passed along the entire north shore and identified gabbro at several localities, but saw no slate. There is no range of hills along the shore.

§ 20.—NORTH FOWL LAKE.

This and South Fowl lake are by Dr. Norwood designated jointly "Lac du Coq"; but in the terms of the Webster-Ashburton treaty they are named as in this report. North Fowl lake has an outline resembling the vertical section of a fleshy mushroom. The stem is directed southward. The north and south dimension of the lake is two miles, and the width of the cap is two miles. The lake is nested in a depression among high gabbro-crowned hills These are not less conspicuous on the Canadian than on the American side.

The portage east out of Moose lake is really about three-fourths of a mile long, though the plat shows less. It is crooked, rough and overgrown with bushes: and like the other trails along this part of the boundary appears to be little used. The clearing at the termination marks the site of a former winter house of the Hudson's Bay company. Pigeon river is now a good sized creek, flowing more rapidly than Burntside river, but probably carrying about the same amount of water.

A gabbro and slate range runs parallel with the river, on the south side, and the same range extends along the southwest shore of North Fowl lake. The gabbro, which was nearly interrupted along Moose lake, near the shore, shows a thickness here of 40 to 60 or 75 feet. The gabbro crests also, lie nearer the level of the lake. A very high gabbro cliff, however, is seen on the Canadian side, which I estimate at 250 feet above the lake; and a series of four others, diminishing in altitude, succeeds southward.

On the American side, in section 26, is the highest precipitous face of gabbro which I have seen. I think what is visible above the talus rises 90 feet—all gabbro—and its base is not over eight feet above the lake. The range strikes from here southward.

This lake is much grown with rushes and wild rice, especially on e American side.

A gabbro range is seen again on the south, gradually rising toward he northeast; and behind this, more easterly, another. Both present recipitous fronts toward the lake. Still farther south is a higher range, rising probably 300 feet, and showing a long perpendicular wall facing northward. This is a mile from the lake, on the American side,—the intervening distance being low and level, and beginning with an extensive tamarack and spruce swamp. These, however, face South Fowl lake, and separate it from Roy lake.

Coming into Pigeon river again, we find a broad, deep, clear, stream, forty feet wide, and bordered by a marsh averaging a quarter of a mile. The marsh abounds in wild rice, cane and an aquatic grass

Pigeon river issues half a mile northeast of the extreme point of North Fowl lake. At that extreme point, a small stream comes in from Roy lake, discharging the waters of Roy, John, McFarland and Pine lakes. In ascending this stream, within less than half a mile, *vertical*, thin-bedded slates are seen in the bottom, obstructing navigation. They are of an ashen color, and apparently would make good roofing slates. This is in sec. 2, T. 64, R. 3 E. This information is obtained from Capt. Wm. P. Spalding, of Sault Ste Marie.

Supposing the information correct, the vertical ash-colored slates can be no other than the Kewatin formation so extensively developed north of Gunflint lake. This, then, is the most easterly point at which that formation has been identified in northeastern Minnesota.

On sections 4 and 5, T. 64-2E. Capt. Spalding has located a quartz vein said to bear native silver and gold on the foot wall. Close by, are what he regards as "ancient diggings," on the south side of "lake Miranda." I have not seen Capt. Spalding's location, but I have seen a sample of the gangue said to hold silver and have in my possession numerous photographs of the vertical quartz vein and the surrounding region.*

§ 21.—SOUTH FOWL LAKE.

South Fowl lake, the last on the national boundary, trends meridionally with its longer axis which is a mile and a quarter in length.

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* For an account of Spalding's mining location, and of the "ancient diggings," so-called, see N H. Winchell, in *Seventh Ann. Rep. Geol. Minn.*, pp. 18-20. The same *report* contains accounts of al other mining locations in the vicinity. See pages 11 to 22.

A further description of the geology of the region by N. H. Winchell is contained in the *Ninth An*

7-79.

The east-west diameter is two-thirds of a mile. The stream connecting it with North Fowl lake is broad and deep, with a barely perceptible current. It widens gradually into the lake. The upper end of the lake presents a wide expanse of wild rice and grasses and seems to be a continuation of the river.

The high gabbro hills mentioned above look down on the lake from the west and south. The outlet is through a gabbro gateway. Through this the river passes over a succession of rapids for over a mile; and nowhere below do the conditions exist for the accumulation of another lake, until the stream is discharged into lake Superior.

S. W. ¼, N.E. ¼, sec. 12, T. 64-3E. An exposure on the hill side a quarter of a mile west of the outlet of South Fowl lake a few rods back from the shore was examined. It is nothing but the familiar coarse crumbling gabbro.

S. W. ¼, N. E. ¼, sec. 12, T. 64-3E. West side of outlet of South Fowl lake. On this side of the gabbro gateway rises a precipitous wall to a hight of nearly 200 feet above the lake. The vertical ascent is about 120 feet. The gabbro where unweathered, is of medium coarseness, abounding in magnetite.

In the midst of the face of gabbro is a vertical dike 27 feet wide, which exhibits a horizontal bedded or quasi-columnar structure. The beds (or columns) are six to ten inches thick, and placed between the vertical columns of gabbro, present from the lake, the appearance of a tier of shelves. The dike intersects the whole exposed face of the gabbro from summit to upper boarder of the talus. It wears away more rapidly than the gabbro, and hence appears in a shallow recess.

The dike rock is very fine-grained, dark gray and nearly cryptocrystalline; but under the lens, reveals the existence of a dark constituent intimately mingled with a translucent, waxy feldspar. It has a high specific gravity.

In a fissure of the gabbro, I found some crystals of dolomite and quartz.

Rock 765. Gabbro from Pigeon river gateway.
Rock 766. Dolomite and quartz, from the gabbro.
Rock 767. Diabase from the dike.

A photographic view of this cliff was taken from the Canadian side, Pigeon river gateway, where rises a gabbro bluff which I estimate at 150 feet high, with a vertical ascent of 75 feet. These are the two sides of the gateway, through which the Pigeon river passes by a succession of cascades out of the last lake in the boundary series. The

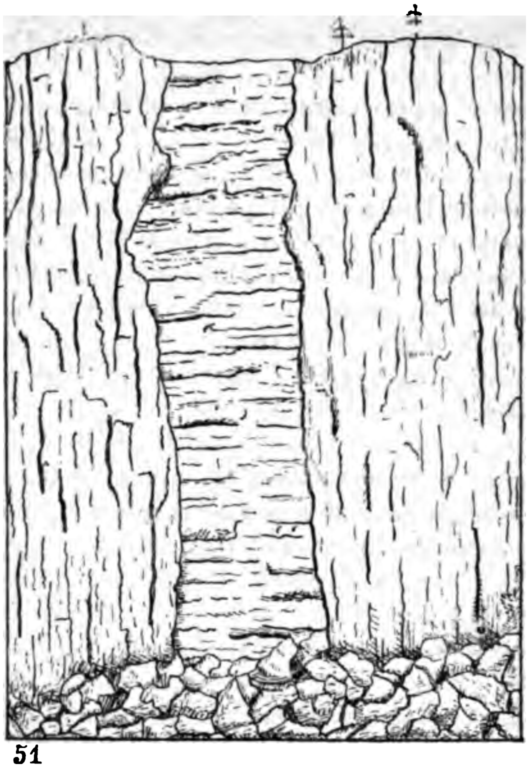

Fig. 51 —*Horizontal columnar structure in the dike on the shore of South Fowl lake. The dike intersects gabbro having a vertical columnar structure.*

gabbro, as everywhere, assumes a columnar structure. I find here no continuation of the dike (of rock 767).

N. E. ¼, S. E. ¼, sec. 12, T. 64-3E. Gateway mountain, commencement of portage out of South Fowl lake, southeastward. Here on the south side is a hill topped with gabbro and 125 feet high. On the north is a towering precipice three hundred feet above the lake, whose jagged outline projects itself against the sky almost in the neighborhood of the zenith. There hang huge parallelopipedons of gabbro awaiting the next season's frosts to be thrown down. Here by the trail, are the enormous masses which were projected from that giddy altitude by some previous season's frosts—ten by fifteen feet in dimension—lying here mostly moss-grown and crumbling away while the centuries roll around. Here are some too, freshly fallen, and above are the scars showing whence they were detached. It is a wonderful place, and provokes a multitude of reflections which must not here be indulged in. This high hill, for clearness of description I call Gateway mountain.

With the view of approximating its true altitude, I used my clinometer and found the angle of elevation to the summit 62°. I simply estimate my distance from the foot of the perpendicular, at 140 feet, and from these data I calculate trigonometrically an altitude of 263 feet. As my point of observation was at least 25 feet above the lake, the altitude of Gateway mountain as thus obtained, is 288 feet. Norwood says it is 306 feet, but does not state whether this is a rough estimate or the result of actual observation.

I took a successful photograph of Gateway mountain with point of view at Halt 1398 [*]

A small spring of ice-cold water issues from the accumulation of *debris* in the gorge between Gateway mountain and the portage trail, and it has been suggested that it may be supplied from a store of ice covered and protected by the mass of fragments.[†]

S. E. ¼, N. E. ¼, sec. 18, T. 64-4E. South end of Long portage, out of South Fowl lake. Walked first over the portage and returned, exclusively for observation. I find it about a mile and a half by the windings. The portage is uncommonly good, though sinuous. I do not understand why so much better than any seen this side of Rove lake.[‡] I can conjecture, however, that the Fowl lakes yield crops of wild rice which bring the Grand Portage Indians up here.

I saw no rock in place on the way; but of course, many gabbro bowlders, and quite a quantity of fragments of black, thin-laminated slate. The country from the eastward slope of this portage, presents a changed aspect. No high ridges intercept the distant view. There are no gabbro knobs or ranges visible after leaving those magnificent monuments of a fiery flood which looks down on us at the Gateway.

I had not intended to travel farther along the Pigeon river; but the interest excited by the changed features of the wilderness led to a change of plan.

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[*] A view of the same is given in Irving's "Preliminary Paper" on the Archæan of the Northwest, *Fifth Ann. Rep. U. S. Geol. Surv*, 1883-4, facing p. 204. The mountain, however, is not in Minnesota but in Canada, being east both of Pigeon river and of the portage.

[†] N. H. Winchell in Ninth Ann. Rep. Minn. Surv., pp. 74-75.

[‡] The whole season's exploration was made without a guide. Nor had any person in my party been through the region previously.

§ 22.—PIGEON RIVER.

The features of the country along the Pigeon river southeast of South Fowl lake will be briefly described in connection with the localities noted. The river, from the foot of the Long portage, continues of nearly uniform width to the next rapids. It is a broad, deep stream, flowing with a current of about a mile an hour. The borders are filled with wild rice and other aquatic grasses. Not much timber is seen on either side. Some scattered tamaracks and clumps of spruces occur. No high land, even in the distance—no upland in the vicinity. Only occasionally clusters of poplars. At length after an interval of two miles, in section 21, T. 64-4E., a small ripple is seen in the current, occasioned apparently by bowlders; but sixteen rods beyond, the sound of rapids is heard.

N. W. ¼, N. E. ¼, sec. 21, T. 64-4E. Fourth portage. This portage is about three-fifths of a mile long, in a mean direction east by south. It strikes the river again on an east-southeast stretch. No rock in place is seen on the way, and but few bowlders. These are gabbro. At the end of the portage, a mountain is seen in the southeast, stretching from southward to northward, but wooded to the summit.

N. W. ¼, N. E. ¼, sec. 21, T. 64-4E. A quarter of a mile further north. Went up to the rapids a few rods above the eastern end of this portage, but found only bowlders as an explanation. Went then, west again to the top of the ridge apparently causing this abrupt northerly bend in the river; following it north to the turn in the stream; but found nowhere any outcrop. I had expected to find evidence of a dike trending north.

N. E. ¼, S. W. ¼, sec. 22, T. 64-4E., as of Minn. Olivine knob. At length we come to a hill on the Canadian side, a quarter of a mile back from the river, whose white-shining rock-exposures remind me again of syenite. I plunged through the intervening swamp and climbed the slope to the summit. It weathers granite-fashion. It is of pepper and salt color. Whitish feldspar is very determinable; and there is a little transparent feldspar. Beside these, are abundant grains of a smoky mineral, and not a few of magnetite. The smoky mineral is harder than feldspar, and weathers conspicuous on the rock surface. When broken, the grains present glassy surfaces. Evidently they answer the description of olivine. This hill is 125 feet high.

Rock 768. Granular olivine gabbro or noryte.

I find incorporated in this formation at the summit of the hill, some characteristic coarse gabbro (769).

From the summit of this hill I take a survey of the surrounding country. West northwest, spreads an area two miles wide and eight miles long, through which we have followed Pigeon river. It is dotted with tamaracks and spruces, but most of the surface is occupied by alders or marsh grasses.

South 40° west is a knob which has an eruptive contour, with a smaller knob for each shoulder. The range to which these belong extends about westward to a point S 85° W. from here, and about one and a half miles distant. From behind this rises a much higher mountain, which seems to be about six miles away. From where it appears, it trends away, west of north, and ends in what appear to be gabbro bluffs N. 80° W. from here They face northward. They seem to be southwest from South Fowl lake. In the nearer ground, N. 75° W., is another bluff, also facing northward. Still nearer, about three miles distant, N. 70° W., is another bluff of less magnitude. On the north is a mountain-like ridge, about three miles distant, running east and west. In a hill on the north, half a mile away, about 75 feet above the river, are outcrops of light color, resembling the rock in this mountain.

N. W. ¼, S W. ¼, sec. 22, T. 64-4E. Third portage. The rapids between the two gabbro hills are portaged on the left of the stream. Portage one-third of a mile, direction a little east of south.

Below these rapids, for a mile and a half, the stream is swift, and interrupted by many bowlders of trap. In places, it widens out and becomes very shallow. In one place it divides, and runs among many islands. Neither stream has water enough for safe canoeing, and navigation is very difficult. The bowlders passed, the stream becomes 50 to 60 feet wide, and three feet deep. This is a long stretch of a mile, flowing eastward.

At this place one sees in the east, at the distance of a mile or two, a trap-looking hill seventy-five feet high. The stream flows directly toward it until within a quarter of a mile, when it turns abruptly northward and then eastward, to pass around the hill.

T. 64-5E. has not been surveyed because lying in the Indian Reservation. At a point in the pass between the hill above mentioned and a smaller one on the Canadian side, I ascended the latter. I found it a very compact and hard sort of gabbro (770) with much olivine and magnetite.

The cliff on the American side looks exactly like this.

Partridge portage. The stream along the stretch of a mile between the last and this point is bordered by weeds and flows quietly through a level tract.

The plane is mostly a clearing, but some poplar, birch and firs remain. Partridge portage is about a quarter of a mile long, fairly good.

Partridge falls. The Minnehaha of the boundary.

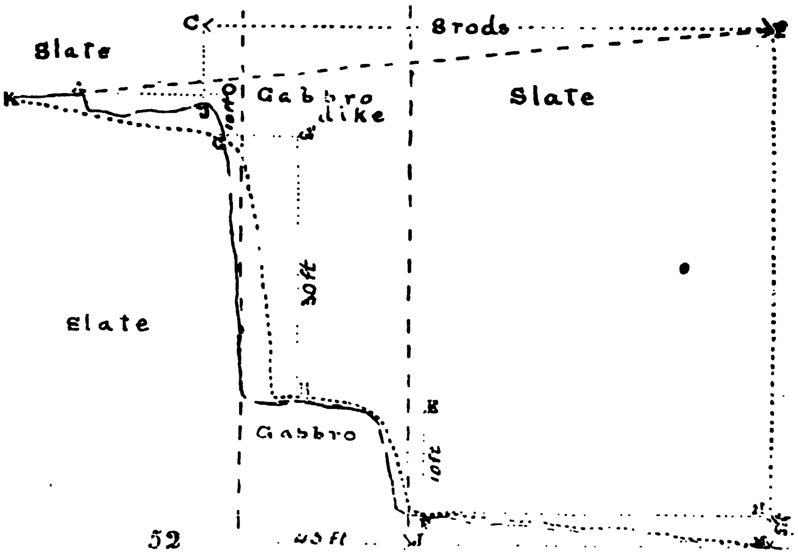

Fig. 52.—*Diagram of Partridge falls in Pigeon river.*

The measurements given are estimated. The diagram is not drawn to a scale.

A. The highest rock above the falls.
B. The hight at which it reached at the foot of the descent.
C B. Eight rods, distance from brink of falls to foot of rapids.
D. Standing rock at brink of falls (place of Indian in photograph.)
E F. Ten feet, hight of lower falls.
G H. Thirty feet, hight of upper falls.
I J. Width of dike of gabbro, 45 feet.
K G. Rapids above the falls. Descent, O G. 20 feet.
F M. Rapids below the falls. Descent, M N. 5 feet.
K G H F M. Surface of water.

The above diagram shows the more important facts. The highest rock, A, slopes upward at such angle that if continued to the standing place, D, close to the falls, it would be ten feet above it. A dike of gabbro, which seems to be of the same character as the gabbro of the country, intersects the formation between the two falls and is about

45 feet wide. If this proves to be the same as the ordinary gabbro, it would seem probable that it was contemporaneous in eruption, and that this was one of the fissures from which the flow came which inundated the country. Further, as no gabbro appears on the surface in the vicinity, there is evidence of much erosion of gabbro. And still further, if one gabbro vent of small dimensions existed, not unlikely the whole escape of the outflow was through numerous vents of moderate capacity, rather than one or two great fissures.

The strike of this dike is N. 55° W. and it stands about vertical. N. H. Winchell says, "W 5° N." (Ninth Rep. p. 74).

The dip of the slates here is up-stream, and since the stream here flows northwardly, the dip is southward, Norwood says, "Above the falls, the dip of the slate is northwest, 80°." Below, he says the dip is "reversed to the southeast, at an angle of 17°." N. H. Winchell says, on the contrary, "The brink of the falls is of slate, ripple-marked, dipping south about 12°;" and Bell says "the slate dip south about 20°."

Rock 771. Animike black slate from Partridge falls.

Rock 774. Gabbro from dike at Partridge falls.

Rock 775. Specimen illustrating jointage of slate.

I took much pains to get good positions in the gorge below the falls, for photographic views, and obtained four successful ones. A very good general view of Partridge falls is published in professor Irving's "*Preliminary Paper*" *

Grand portage, seven miles from lake Superior. The river through the stretch of two and a half miles between Partridge falls and this point, pursues a very sinuous course over a grassy plain evidently underlaid by Animike black slates in a position nearly horizontal. At this portage is an old clearing of a few acres, overgrown with wild grasses. Dr. Norwood states that this "was once the site of Fort Charlotte, for many years the most important post of the Northwest Fur Company."

The rapids here pass over a dark gray, partly thick-bedded slate, dipping southward about 6°.

Rock 772. Prevailing character of the slate, at the upper end of the Grand portage.

Rock 773. Darker, thick-bedded slate.

The Pigeon river valley, east of the great swamp—that is, below the gabbro range, is decidedly tillable. Most of it is upland, with a good natural soil, as evinced by the rank growth of herbaceous vegetation. There are few hills, and seldom outcropping rocks. The country has been once burned over, on both sides of the river, and many of the dead pine trunks still stand to attest the once vigorous growth of the forest. The Indian Reservation, on the American side, as far as can be seen, is a level, arable and valuable tract.

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* *Fifth Ann Rep. U. S. Geol. Surv* facing page 203.

It may be added, for the purpose of completing a view of the boundary as far as Pigeon Point, that its physical and geological features below the upper end of the Grand portage are already pretty well understood, and have been described with more than his usual detail by Dr. Norwood, assisted by Major Richard Owen. His descriptions embrace also the shore line between Pigeon Point and Grand Portage bay, as well as the geology of the Grand portage.* A careful report on the same district has been published by Prof. N. H. Winchell.† An exposition of some special features has recently been published by professor W. S Bayley.‡

The course of this report now returns westward to Red Rock lake with a view to considering in regular succession a series of lakes lying next south of the boundary series, to which our attention has thus far been confined.

§ 23.—RED ROCK LAKE.

The passage from the west long arm of Saganaga lake to Red Rock lake is narrow and obstructed by syenitic bowlders. A small stream flows out of the latter lake. Red Rock lake is practically a continuation of the west long arm mentioned. It is similarly indented by long capes, with alternating deep, irregular, mostly club-shaped bays. Its shores are exceedingly rocky, and buttressed by frequent high, often precipitous boses of syenite. A few intervening soil-covered tracts occur on which grow small spruces and Jack pines. The region possesses little value either or timber or agricultural purposes.

From Saganaga lake sec. 28, 66-5, syenite continues unchanged in character to Red Rock lake. When the shallow passage between the two is not canoeable, a short portage may be found over the hill on the east side. The direction of the current is out of Red Rock lake, but the stream is hardly a rapid.

N. W. ¼, S. E. ¼, sec. 28, T 66-5. Passage from Saganaga to Red

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* Owen's Geolog Survey of Wis , Iowa and Minn , pp. 397-409.

† *Ninth Ann. Rep. Geol. Minn.* 1880, pp. 61-73. Mining geology also in *Seventh Ann. Rep.* Minn. 1878, pp. 14-19. See also *Tenth Ann. Rep.* 1881, pp. 43-49.

‡ Bayley, *On some peculiarly spotted rocks from Pigeon Point, Minn. Am Jour Sci.* III, xxxv 388-93, May, 1888

Rock lake. Syenite, still weathering conspicuously rough, with large quartz grains.

S. E. ¼, S. W. ¼, sec 28, T. 66-5. Syenite (576) unchanged.

S. E ¼, S. W. ¼, sec. 33, T. 66-5. Numerous examinations made from the last point to this reveal no important variations in the character of the syenite. At this place is a lofty vertical wall of syenite, some of whose faces are covered by an orange-colored lichen (577). This, I suspect, is the particular "red rock" from which the lake is named. (Compare "Painted Castle," p. 115, Report of 1886). The syenite is still unchanged.

The syenite continues without change to the southern extremity of the lake.

No water communication exists between Red Rock and West Seagull lakes. The portage goes out at the extreme southwestern angle of the former. It passes over a depressed ridge, through open woods consisting of Jack pine and spruce, with a few poplars. It is an unfrequented trail, but quite practicable. We chopped out a number of trees fallen across the path.

§ 24.—WEST SEAGULL LAKE.

West Seagull lake lies in the northwestern part of T. 65-5, with an extreme length north and south of about two miles and a breadth a little less On the plat it presents a strinkingly irregular figure; and the numerous large islands included cause an appearance of a jagged inlet winding and ramifying through a wilderness of rocky knobs. The exposures of syenite are almost continuous until we approach the southern extremity. In this region the syenite becomes chloritic, gneissic and even schistic. On the west of Seagull lake, in section 7, Mr. Stacy reports "conglomerate and syenite interbedded"; but I had left the region before obtaining this information. Mr. Stacy compared the conglomerate with that of Ogishke-muncie; but I feel strongly persuaded that the two are very different. The latter is remote from syenite and has never been seen interbedded with crystalline schists—still less gneisses. I suspect the West Seagull conglomerate is to be compared with that of Wonder Island in lake Saganaga; and I think undoubtedly the greenstone pebbles and bowlders disseminated through this syenite-gneiss formation generally are closely connected with the history of these conglomeritic beds and patches.

S. E. ¼, N. E. ¼, sec. 5, T. 65-5. South end of portage from Red Rock lake. Syenite exactly as on Red Rock lake.

S. E. ¼, S. W. ¼, sec. 5, T. 65-5. West side of north part of lake. Here are vast exposures of syenite (578) along the west shore. It looks white at a distance and presents a wide shining treeless area rising toward the interior. On examination, it closely resembles that so prevalent; but the quartz grains are a little smaller, and the surfaces of the rock do not weather so rough.

A high range is seen on the east and southeast, appearing 300 feet high. It appears to be southwest of Seagull lake and east of Frog Rock lake.

S. W. cor. sec. 8, T. 65-5. Syenite without conspicuous quartz grains, and with a chloritic mineral in place of hornblende (579). Portions of the rock abound in the chloritic mineral. The formation resembles that seen on entering Saganaga lake

Rock 580. Chlorite syenite, highly chloritic, like Pipestone chlorite gneiss. (Compare Report for 1886, pp. 105-6- 176-7).

N. E. ¼, N. W. ¼, sec. 17, T. 65-5. A quarter of a mile beyond the last point. The formation has become graywacke-like. It attains, as usual for the graywackenitic rocks of the entire region, a very massive development. This is near the southern point of West Seagull lake.

Rock 581. Graywacke, dark and fine.

N. E. ¼. N. W. ¼, sec. 17, T. 65-5. Southern point (head) of West Seagull lake. Massive graywacke (502) a little slaty in places.

N. W. ¼, N. E. ¼, sec. 17, T. 65-5. One-eighth mile northeast of southern point of West Seagull lake. At the beach, chlorite schist. A few steps back, syenite gneiss with red feldspar, alternating and mixed with chlorite schist. One example follows:

The schist in places approaches the condition of a greenstone. The gneiss has the common character, with pale red feldspar and scattered grains of quartz.

Rock 573. Gneiss and chloritic rock in contact.

The small island off this locality is composed of chlorite syenite; and the point projecting in from the east is the same.

S. E. ¼, S. W. ¼, sec. 8, T. 65-5. Island north of the extremity of the point last mentioned. Quartziferous granular felsyte (843) very similar to that seen in the west long arm of Saganaga lake.

This island is scarcely half a mile north of the head of West Seagull lake, and the "point" is nearly midway between them.

The cape jutting northward less than half a mile east, is composed of chlorite syenite; while the large island between the cap and the east shore is of syenite of the usual sort for this region.

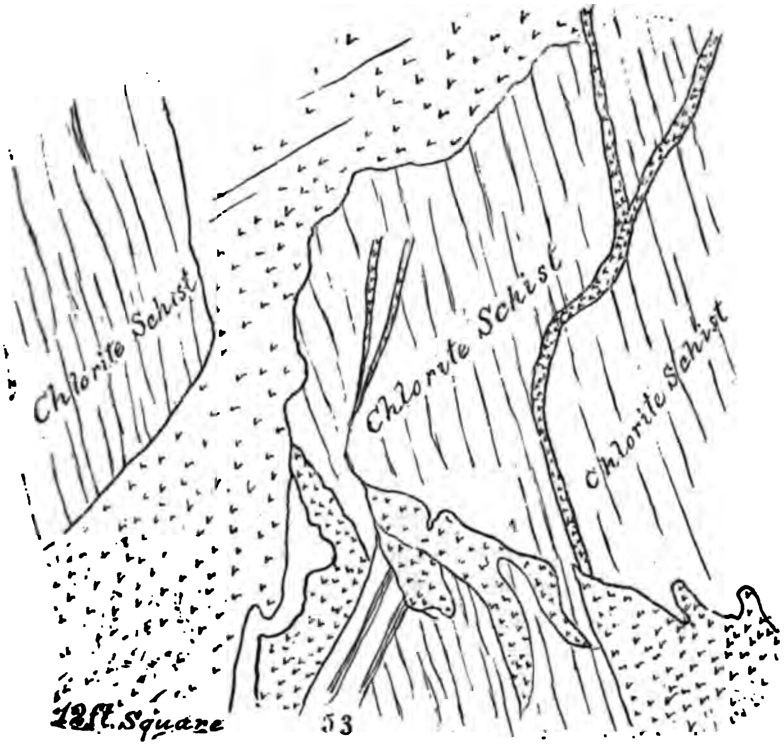


Fig. 53.—*Intermixture of syenite gneiss and chlorite schist, West Seagull lake.*

S. E. ¼, N. W. ¼, sec. 9, T. 65-5. East side of West Seagull lake. Syenite (594) with well formed hornblende; but the grains of quartz are not remarkably large, nor do they stand conspicuous on weathered surfaces.

S. E. ¼, S. W. ¼, sec. 4, T. 65-5. Neck of the most eastward bay of West Seagull lake. Syenite with large quartz grains.

S. E. ¼, N. E. ¼, sec. 9, T. 65-5. On the rapids from West Seagull to Seagull lake. Chlorite syenite.

The stream connecting these two lakes is over half a mile long, flowing toward Seagull lake. The rapid requires no portage.

§ 25.— SEAGULL LAKE.

This is located mainly in T. 65-5, but extends half a mile into T. 66-5 and 4, and a mile and a half into T. 65-4, thus covering the corner of four townships. The features of the lake in the vicinity of the four corners are shown in the sketch-map, figure 54, which shows the connection with Saganaga lake through the arm called Seagull river. This lake has an extreme length, northeast and southwest, of about six miles, with a main breadth of nearly two miles. The west body of the lake is a clear expanse of three square miles only interrupted by small islands near the western shore. The east body however abounds in large islands which occupy half the area. Cucumber island is two miles and a half long, with a mean breadth of nearly half a mile. A high ridge runs longitudinally through it. The original forest still stands, composed largely of Norway pine and spruce. In the region west of Cucumber island, the large, lofty, bald syenitic islands rise very conspicuously. On the north shore is a syenite promontory which attains an elevation of 150 feet. Two interesting features are presented by the syenite of this lake. First, its passage through chlorite syenite on the south, toward the chlorite schist and argillytes pertaining to the Knife lake belt, and Second the general dissemniation of greenestone pebbles in the gneiss which proves premonitory of the contiguity of actual conglomerate patches imbedded in the gneissic terrane, as already described on Wonder island in Sagnaga lake, and mentioned in connection with West Seagull lake.

Partaking of the general sterile character of the entire region traversed by the Giant's Range, the vicinity of Seagull lake possesses few inducements for settlement, and gives no promise of important mineral discoveries. Building stone is the chief product of the region

There seems to be no portage around the rapids between West Seagull and Seagull lakes. The stream is mostly broad and sufficiently deep for canoeing; but some of the rapids are rather exciting.

N. E ¼, S. E ¼, sec. 9, T. 65–5. South of the mouth of the stream. Chlorite syenite.

S. W. ¼, S. W. ¼, sec. 10, T. 65–5. Island nearest the last. Syenite with partially developed hornblende.

S. W. cor. sec. 10, T. 65–5. Point of cape from the west. Syenite like last, but the hornblende is imperfect.

N. E. ¼, N. E. ¼, sec. 16, T. 65–5. Entrance to broad westward bay. Syenite with hornblende distinct.

N. E. ¼, S. E. ¼, sec. 16, T. 65–5. Nearest island to south point o bay. Syenite as before.

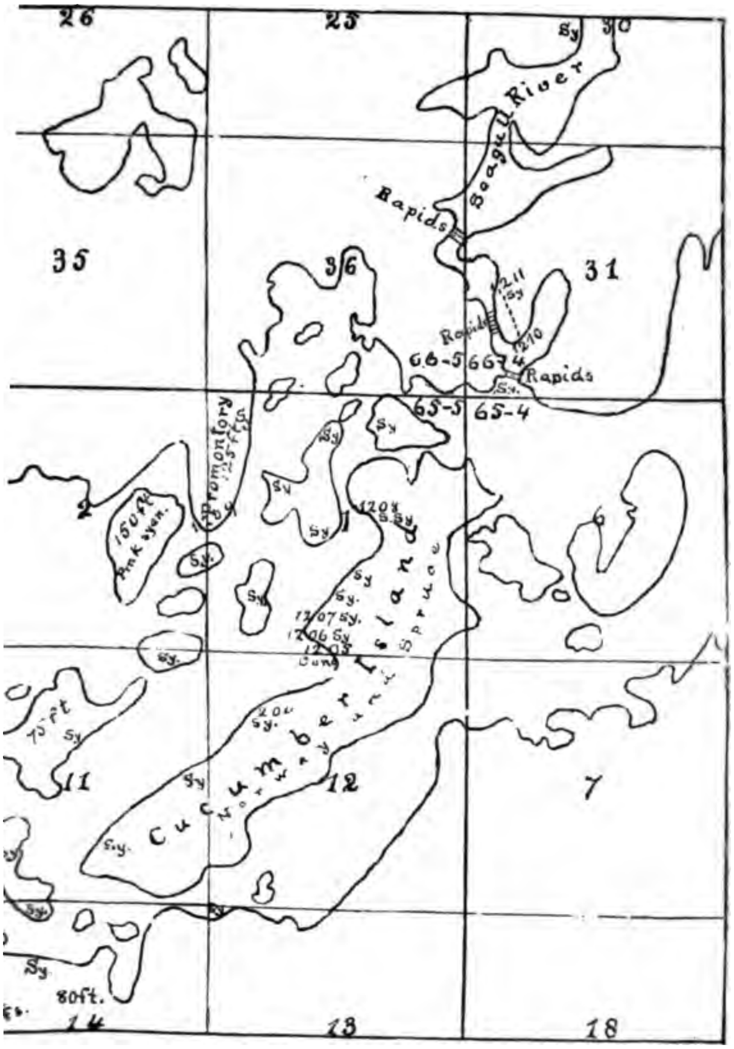
S. W. ¼. S. W. ¼. sec. 15, T. 65–5. Near southern extremity Syenite weathering white. This may be compared with syenite (57 on west shore of West Seagull lake. The quartz exists in larg grains.

¼, S. E. ¼, sec. 15, T. 65–5. Syenite (595) very well marked. ornblende is somewhat chloritized.

ands in this vicinity are of syenite. A high massive cliff ex- ng south side of narrow, eastward projecting bay. The two xt northeast are of common syenite, and a high cliff is ex- the southern one.

vation of many shores and islands on the southeastern and parts of the lake proves them all to be formed of the prevail-

mainder of this lake is illustrated by the following map:



4.—*North part of Sea Gull lake, Ts.* 66-5 *and* 4 *and* 65-5 *and* 4.
Land and water contours in a granitic region.

either augitic or chloritic; but imbedded in this are needles and laminæ of glassy feldspar.

But besides these, are pebbles or pieces, generally smaller than the others, which are composed of a chloritic substance, and, if I mistake not, themselves contain angular fragments like the chloritic conglomerate, number 597.

Again a chloritic rock material is sometimes included between masses of syenite-like sedimentary sheets, with the fine lamination, or at least, structural lines running parallel with the syenite surfaces. Parts of these sheets contain irregularly disseminated fragments of pink feldspar.

Rock 599.	Saganaga syenite—ordinary appearance.
Rock 600.	Fine granulyte included in above.
Rock 601.	Syenite including pieces of chlorite rock.
Rock 602.	Piece of included chlorite rock.
Rock 603.	Included chlorite schist.
Rock 604.	Pebble of fine syenite.
Rock 605.	Same fine syenite stratified.
Rock 606.	Pebble of chloritic diabase.
Rock 607.	Syenite with carbonate of copper.

All the islands in this vicinity were visited, but common Saganaga syenite everywhere prevails.

S. W. ¼, sec. 31, T. 66-4. South end of portage around rapids into so-called "Seagull river"—short navigable rapids having been already passed twenty rods to the south. Still syenite (608), but the hornblende is here more abundant and blacker. The quartz is much less abundant, and the feldspar individuals are well isolated.

This portage is about a quarter of a mile, along the east side of the rapids.

The "rapids" so-marked on the plat, a few rods farther north may be navigated.

§ 26.—LOON LAKE.

Loon lake lies in the southern part of T. 65-3W. It is nearly four miles long east and west, and for most of its length half a mile wide, but expanding toward the eastern end to more than a mile in width. On the south side of the lake is a high mountainous peninsula, a mile and a quarter long, trending east and west, with an isthmus ten rods wide and bounded on the south by a slender arm of the lake about fifteen rods broad. Loon lake is hemmed in by lofty ranges of gabbro-covered Animike slate hills lying on the north and south, but much more precipitous and lofty on the south.

The whole region has been burned over; but small patches of the original forest remain, and low lying slopes are already reclothed with thrifty young trees of poplars and birch.

This lake lies wholly within the Animike region, and many characteristic cliffs of gabbro-covered black argillyte and siliceous schist rise along the south shore. Porphyries abound on the north shore.

The principal portage to Loon lake passes out from the western extremity of the little peninsula in sec. 23, on the south shore of Gunflint lake. It winds over a pass in the Mesabi range, a distance of three-quarters of a mile. The portage is little frequented and rather difficult from the intervention of hills, rocks and fallen timber.

S. W. ¼, N. E. ¼, sec. 26, T. 65-3. Near termination of portage, on the west. An unusual rock. A groundmass of a gray color, apparently composed of feldspar and augite. Abundant parallelopipedons of a waxy, striated feldspar disseminated through the groundmass.

Rock 691. Porphyritic noryte.

It occurs in a low exposure close to the water on the north shore.

N E. ¼, S. W. ¼. sec. 26, T. 65-3. Half a mile further west. Gabbro (692) in a low outcrop.

N. W. ¼, S. W. ¼, sec. 26, T. 65-3. Forty rods still west. A very interesting rock resembling syenite, very hornblendic or perhaps augitic, with reddish feldspar in small grains generally distributed, and in places clustered.

Rock 693. Resembling syenite, but probably gabbrolitic.

A few steps back, a more massive outcrop occurs, which, while containing some reddish feldspar, has a decidedly gabbrolitic aspect, especially on weathered surfaces. Contains also, a whitish feldspar.

Rock 694. Gabbrolitic rock.

S. W. ¼, S. W. ¼, sec. 26, T. 65-3. Forty rods west of the last. Syenite looking rock again (695) but it is probably noryte.

It has a dark crystalline groundmass, reddish feldspar prisms and grains disseminated; also a most abundant dull waxy feldspar.

S. E. ¼, S E. ¼, sec. 27, T. 65-3. Close by the last. Appears like a simple, fine-grained diabase; but, considering the association, I shall set it down as noryte—696.

S. E. ¼, S. E. ¼. sec. 27, T. 65-3. Within ten steps of rock 696. A low, exposed point of rock like that of rock 691. The weathered surface is remarkable. There appears a groundmass composed of fine black crystals mingled with sharp-cornered slightly larger crystals of a reddish feldspar. In this groundmass are disseminated white-weathering crystals and masses of a pale waxy feldspar attaining dimensions up to an inch and more in diameter.

The freshly broken surface presents a groundmass with the elements less individualized, and the coarse feldspar pale-waxy, faintly striated —it being very difficult under a Coddington lens to detect the lines.

Rock 697. Porphyritic noryte.

This would be an admirable rock for inside decoration, its red-specked groundmass studded with pleasingly tinted, four-angled crystals and rounded forms of feldspar.

S. E ¼, S. E. ¼, sec. 27, T. 65-3. Close by rock 697. Resembling outcrop, rock 693—syenite-looking.

S. W. ¼, S. E. ¼, sec. 27, T. 65-3. Twenty rods west. Compact, medium-grained gabbro (698), with plates and masses of shining magnetite.

S. W. ¼, S E. ¼, sec. 27, T. 65-3. Less than a mile and a half from where I first struck this lake. Gabbro above medium coarseness.

S. W. ¼, S. W. ¼, sec. 27, T. 65-3. Porphyritic noryte identical with that of rock 697, but the reddish constituent of the groundmass much less abundant, and hence not so fine for decorative purposes.

S. W. ¼, S. W. ¼, sec. 27, T. 65-3. Close by the last. Fine, uniformly tinted noryte (699), with considerable fine, disseminated pyrites.

S W. ¼, S. W. ¼, sec. 27, T. 65-3. Four rods west of 699. Formation appears bedded, with a low dip northeast; but examination shows it a fine dark gray homogeneous rock with thin scales waxy-translucent; and I feel compelled to put this down also in the same group as the other varieties seen.

Rock 700. Noryte exceedingly fine, almost aphanitic.

S E. ¼, S. E. ¼, sec. 28, T. 65-3. Porphyritic noryte in a high exposure.

S. W ¼, S. E. ¼, sec. 28, T. 65-3. One mile from western extremity of Loon lake, north shore. Gabbro (701) of medium coarseness again.

N. W. ¼, N. W. ¼, sec. 33, T. 65-3. Half mile from west end of lake. Low exposure of porphyritic noryte.

N. W. ¼, N. W. ¼, sec. 33, T. 65-3. Formation like that at rock 700, but a little coarser.

Rock 702. Fine-grained noryte.

Within a few feet occurs the porphyritic noryte, and then, a few feet further, the fine noryte recurs.

A few rods further west, the noryte is coarser.

Next comes the porphyry again — a large outcrop.

The fine noryte recurs — all the exposures toward the western extremity of the lake being larger than those more easterly.

N. E. ¼, N. E. ¼, sec. 32, T. 65-3. Near west end of lake. Noticing a whitish sort of rock exposed in the hill north of the western end of the lake, I went up to it, and found it simply gabbro with a dark waxy or reddish feldspar which weathers nearly white, and produces a striking speckled appearance on the rock. Some of this is porphyritic.

Rock 703. Gabbro, with weathered surface and peroxidized iron in a portion.

Rock 704. Gabbro with large augitic crystals weathered out.

S. W. ¼, N. E. ¼, sec. 32, T. 65-3. End of lake. A high cliff at the west extremity of the lake exposes some white-weathering gabbro quite conspicuously. Examination shows other portions very fine (705); and some portions have weathered with a conspicuous iron stain, giving the appearance of an iron mine.

Noryte or gabbro, crumbling and rusty, extends eastward along south shore, falling down from ledges 40 feet above, and forming a talus.

N. E. ¼, N. W. ¼, sec. 32, T. 65-3. Half mile from west end. An exposure of slate, about 25 feet high, having a dip of 16° in a direction S. 80° E. (according to needle, which may be locally affected.) The slate occurs in beds three to four inches thick. Some of them are hard and ringing when struck with the hammer, having a very compact and fine-grained structure, iron-gray in color, and with abundant fine scale-like mineral disseminated through it, shining like pyrites, but possibly magnetite. Some samples have a shining, pyrites-like mineral accumulated in little circular areas, giving the appearance of thin fish-scales.

The form of the rock first described is exactly that of 699 and 700, which I did not recognize as slate, though the latter was observed to be actually bedded.

Rock 706. Slate, prevailing condition.

Rock 707. Slate, with dark, scale-like areas.

S. E. ¼, N. E. ¼, sec. 34, T. 65-3. Middle of south side. Large angular fragments of solid gabbro.

N. W. ¼, N. W. ¼, sec. 35, T. 65-3. Close by the last. Compact slate, like that of 706 and 707, in a low outcrop.

N. W. ¼, N. W. ¼, sec. 35, T. 65-3. Very near the last. Fine, gabbro-looking, but the formation is in massive beds dipping E. S. E. about 8° or 10°, and I suspect it belongs to the slate formation.

Rock 708. Gabbroloid slate?

Above 40 feet, the rock looks more massive.

A gabbro-like crest continues along this ridge, terminating in a hill about 150 feet high, with a precipitous brow hanging perpendicularly 35 feet.

1. N. E. ¼, N. W. ¼, sec. 35, T. 65-3. One-fourth mile from the last. The brow of gabbro almost overhangs this spot; but at the bottom here is an exposure of slate dipping 13° in a direction about south (according to the compass and according to estimation). The slate is mostly hard and ringing, dark gray, and exceedingly fine textured. Some of the thinner layers are darker and more argillitic. In bands or zones there are laminæ not over a thirty-second of an inch thick.

Rock 709. Prevailing character of the slate.

Rock 710. A thin layer, dark, argillitic.

Rock 711. Thin laminæ.

Rock 712. Specimen about 8 feet above water.

Rock 713. Specimen 20 feet above water.

Moving out into the lake, the bedded structure can be distinctly seen to a hight of 80 feet. Above this for 40 feet, the rock has a massive gabbro-like aspect.

N. W. ¼, N. W. ¼, sec. 36, T. 65-3. East end of long peninsula. Gabbro.

On the main land south of the peninsula, are exposures along the brow of the ridge, which weather like gabbro. No outcrop, however, appears along the shore.

N. E. ¼, N. W. ¼, sec. 36, T. 65-3. East end Loon lake. A good exposure of a massive character, without an indication of bedding. But examination shows it to be of the character of the magnetitic slate.

Rock 714. Magnetitic slate, showing no bedding.

N. W. ¼, N. W. ¼, sec. 36, T. 65-3. Near point of cape. East end. A fine-textured, uniformly dark gray rock, in which the elements of a noryte can be discerned.

S. W. ¼, S. W. ¼, sec. 25, T. 65-3. On the cape, north of point. A cliff of slate 125 feet high, having gentle dip southward.

This is succeeded easterly by a precipice of gabbro. This, at the eastern end forms a perpendicular face 35 feet high, with quite a basaltic aspect. Below is a talus reaching to the beach.

N. E. ¼, S. W. ¼, sec. 25, T. 65-3. East end, north bay. A low outcrop of medium texture gabbro.

N. E. ¼, S. W. ¼, sec, 25, T. 65–3. Close by the last. Heavy-bedded, eruptive-looking slate—same as at rocks 699, 700 and 706-7.

N. E. ¼, S. E. ¼, sec. 26, T. 65–3. One-third mile west of the last. Low exposure of coarse-grained gabbro.

Rock 715. Coarse-textured porphyry.

Above this is the porphyritic noryte. My use of different terms—noryte and gabbro—cannot be made precise in the field. I name the rock noryte when both the basic plagioclase and the augite are of granular form—they are also generally fine. I call it gabbro when their forms are lamellar or coarsely crystalline—in which case magnetite is more conspicuously present, and sometimes olivine. I think, after making the tour of Loon lake, that perhaps all the erupted rocks are gabbrolitic essentially.

On the portage to Gunflint lake, one-eighth mile from Loon lake. Gabbro of medium texture.

§ 27.—IRON OR MAYHEW LAKE.

This is a long, narrow, east-west lying lake, three miles of which are in the extreme southern part of T. 65–2 W. and one mile in the southeast corner of T. 65–3 W. Its average width does not exceed twenty rods. The shores are only moderately elevated, but generally rocky and irregular in outline, and extending on the south side into one narrow bay three-quarters of a mile in length with its axis southwest by west. The borders of the lake are shaded by a light forest. The narrowness of the lake causes the opposite forests to seem to shut together and exclude the visitor from connection with the world. He seems imprisoned in a narrow slit, from which the strongest impulse is to escape.

The rim of the lake is mostly massive gabbro. This in places is so strongly charged with magnetite that one might truthfully conceive of the prison-lake as iron-bound. The abundance of magnetite caused attention within a few years to be directed to the region, but investigation showed the ore to be strongly titaniferous. Results of details of observations and a chemical analysis are given in the tenth annual report on the geology of Minnesota, pages 80, 81, 82 and 83.

The lake is 161 feet higher than Gunflint lake and 1,213 feet above lake Superior. It is nearly at the elevation of the high gabbro bluffs of the adjacent lakes, Gunflint, Loon, Mountain and others; and this may explain the low-lying relative position of the gabbro shores and islands.

An obscure portage trail goes out from Loon lake at a point on the south shore precisely south of the east point of the long peninsula. It is about half a mile in length and ascends steeply to the summit of the intervening ridge whence a slight descent leads to Iron lake.

S. W ¼, S. E. ¼, sec. 36, T. 65-3. Iron lake. An island half a mile east of end of portage. A naked, crumbling gabbro dome.

Rock 790. Gabbro, coarse, crumbling, highly magnetitic.

The rock is of similar character on the south shore opposite.

N. W. ¼, S. W. ¼, sec. 31, T. 65.2. North shore. Black sheets of magnetite are seen spreading out in the gabbro in an irregular way. Here and there fragments of the gabbro are involved in it. The appearance is as if the magnetite had existed previously and been introduced into the mass of fluid gabbro, and never generally diffused. There is sometimes a green mineral like copper carbonate which I reserved for subsequent examination.

Rock 791. Magnetite in gabbro, with green mineral. Iron lake.

This locality was revisited and more carefully studied. It furnishes a large quantity of titaniferous iron ore.

But the most interesting fact is the occurrence of gabbro unconformable on a sedimentary rock which appears thus far, to belong to the Animike (794). I think it will go with the "Muscovado," studied last year, and which, after careful examination in many places, I concluded to be sedimentary. It contains some quartz and much glassy feldspar. I think it is this bed which in the tenth annual report, p. 81, is referred to as a "gray quartzyte (apparently)," and also, as "appearing like a granular gray quartzyte, but really consisting of the minerals that go to make gabbro."

I find in this vicinity fragments of Animike slate, well rusted; but when broken, a black, lustreless mineral appears which can be traced in outline into the rusted coat. This must be examined.

Rock 795. Rusted Animike slate.

Rock 796. Titaniferous gabbro, with red zone.

This is to be used to ascertain whether the red zone results from change of the magnetite or of olivine.

Rock 797. Muscovado, from fragments on the gabbro—some clearly stratified.

Rock 798. Hornblendic and greenstone pebbles, mixed together in a groundmass of syenite. From a bowlder.

North shore Iron lake east end, in sec. 33, T. 65-2 One of numerous exposures of gabbro containing much magnetite.

Rock 792 Gabbro with titaniferous iron.

Rock 793. From a bowlder, but known to belong to the Animike of Gunflint lake. The rustiness of the exterior awakens curiosity. The rock is to be investigated for chalybite or ankerite. [P. S.—The rock effervesces with acid; but the fully changed red portion does not].

The course of the descriptions here returns west again and takes up the geology of certain lakes belonging to the second series south of the boundary series.

§ 28.—FROG ROCK LAKE.

This small lake is in the western part of T. 65-5, lying chiefly in sec. 18, but extending to the middle of sec. 17 and a short distance into sec. 19. It is southwest from West Seagull lake and drains into it and thence into Seagull and Saganaga. It is surrounded by low, mostly naked hills of dark, solid, eruptive-looking rocks, some of which seem to be highly altered or siliceous conditions of the Kewatin series. It is however, the region of passage from the vertical crystalline schists of West Seagull lake to the vertical earthy schists and conglomerate of Ogishke-muncie lake. Some of the eruptive-looking masses rise in rounded domes 25 to 50 feet above the lake. In the eastward direction are seen hills which appear to be 200 feet high.

I devoted considerable time to this lake and hoped to get an insight into its geology; but the situation is difficult and I can hardly do more than reproduce the facts as I observed them.

The principal approach to the lake is from West Seagull, along a portage about a third of a mile in length, which passes over a treeless hill abounding in geological interest, with the sound of the cascades in the connecting stream arising on the west. We return to the northern extremity of that portage.

N. E ¼, N. W. ¼, sec. 17, T. 65-5. Near foot of portage, not far east of portage landing. The rock exposed on shore is similar to that of 540, Knife lake, but distinctly more schistic, and much less quartzose. It is a felsitic, chloritic argillyte (844) of irregular structure.

Within eight rods, the formation passes to a fine argillo-micaceous schist, of quite normal structure. Still further it becomes greenish, harder, less distinctly bedded. with crystals of feldspar and veins and aggregations of quartz (compare below, rocks 582-90). Further still, the rock becomes a porphyrelloid graywacke of greenish color, containing both opaque and glassy feldspar crystals (compare under rocks 583-90).

Rock 845. Argillo-micaceous schist.

Rock 846. Porphyrelloid graywacke (compare 584).

On an earlier trip over this portage the following observations were recorded:

Massive domes of graywackenitic rock appear, alternating with a handsome and rather striking porphyrel.

One-eighth mile on the portage. The porphyrel contains mostly oblong forms of feldspar, some of which are angular and others rounded. There are also scattered cuboids of quartz exactly like those seen in the characteristic Saganaga syenite—but these are not everywhere distributed. The groundmass appears highly chloritic, and the feldspar individuals are not sharply isolated from it.

In places, the graywacke is quite chloritic, and angular fragments of itself or a less chloritic rock are imbedded in it. This, on the whole, presents a resemblance to the Stuntz conglomerate. In some specimens, the included fragments are more decidedly of the aspect of the Stuntz conglomerate.

Rock 583. The prevailing graywacke.

Rock 584. The prevailing porphyrel.

Rock 585. Conglomeritic, chloritic graywacke.

The graywacke contains iron enough to impart sensibly increased weight. In places it is crystallized in seams and fissures as hæmatite. The rock is also intersected with veins of quartz and of epidote.

In the chloritic portions, where the conglomeritic condition appears, the rock reminds me of that on the south side of Fall lake. But these portions also, are most abundant in iron, and sometimes give a reddish streak (586). In places, the included fragments have a parallel-laminated structure, as if from a sedimentary rock.

Rock 586. Chloritic groundmass with much iron.

Rock 587. Fragment of included laminated, angular mass, with iron and an epidote seam.

As I proceed over the hill, the country rock becomes still more chloritic—in places, hard and jointed; in others standing in vertical irregular, cuneiform laminæ (589). It is cut by occasional veins of quartz (590), one of which is a foot wide.

Frog Rock lake, head of rapids out. Here is a dike of beautiful diabase (591), over which the stream takes its first plunge. But in the midst of the diabase, I find fine graywacke; as if two dikes approached each other.

Rock 592. Graywacke between two masses of diabase.

I took a photographic view of the falls at this place.

S. E. ¼, N. W. ¼, sec. 17, T. 65-5. North shore a few rods from outlet. Compact, massive, bluish rock, weathering schistic, but like felsyte within.

Rock 847. Felsyte schist.

S. E. ¼, N. W. ¼, sec. 17, T. 65-5. Twenty rods further west. Similar to last, but greener. Rock 848.

S. W. ¼, N. W. ¼, sec. 17, T. 65-5. Low dome of handsome diabase (849) in form of a dike.

S. W. ¼, N. W. ¼, sec 17, T. 65-5. Chlorite granulyte—rock 850.

S. W. ¼, N W. ¼, sec. 17, T. 65-5 Less than half a mile from outlet of lake. A low outcrop of a green rock, composed of a green fibrous mineral and a little light feldspar. A greenstone, rock 851.

S. W. ¼, N. W. ¼, sec. 17, T. 65-6. Here (852) the greenstone contains a little more feldspar, and is intersected by a dike of diabase; but no well defined line of contact between the two can be found.

S. E. ¼, N. E. ¼, sec. 18. T. 65-6. Greenstone of a finer texture and harder. Rock 854.

N. E. ¼, N. E. ¼, sec. 18, T. 65–6. Solitary rock.

Rock 855. Greenstone, a little coarser than Rock 854.

S. W. ¼, N. E. ¼, sec. 18, T. 65-5. Greenstone of average character. Glacial striæ S. 19° W.

S. W. ¼, N. E. ¼, sec. 18, T. 65-6. High bluff of sericitic felsyte, similar to rock 847, 848.

Rock 855 bis. Sericitic felsyte schist.

N. W. ¼, S. E. ¼, sec. 18, T. 65-5. Here a dike of compact, fine-grained diabase intersects Rock 855.

S. W. ¼, N. E. ¼, sec. 18, T. 65-5. High bluff of greenish rock, intermediate in appearance between the greenstone and the sericitic felsyte.

Rock 856. Like 855, but harder and darker.

Near centre of sec. 18, T. 65-5. Bluff of fine, grayish-green rock, appearing like the sericitic felsyte schist in a finer state.

Rock 857. Fine, grayish-green sericitic or chloritic felsyte.

Near centre sec. 18, T. 65-6. Camp. A low outcrop of sericitic felsyte (schist?), rock 858; dark, nearly black, rough-weathering, presenting externally quite a resemblance to the chloritic rock at Kawasachong falls, Fall lake In the irregularities of the surface, one can trace, sometimes, courses of fibrous or laminated structure, mostly curved or even abruptly bent; sometimes a jam of lenticular and cuneiform pieces apparently due to systems of jointage; sometimes, a n indescribably rough and jagged aggregate of shapeless pieces. If numberless little balls of stiff flour-coated dough should be pressed together from opposite directions, they would become flattened and lenticular, and would adhere imperfectly; and if then hardened. the mass would present somewhat the structure of this rock, especially if hard baked and subjected to surface abrasion. The pits and cavities of the weathered surfaces of the rock are indefinitely shapeless and ragged, and vary in depth to 4, 6 or 8 inches. No unequivocal bedding can be detected; but there is a prevailing trend in the constituent lenticules; and at intervals, a coincident general division of the mass by planes dipping about 60° westward, and trending S. 10° W. These statements, however, do not apply to all localities in this vicinity.

On breaking the rock, one is impressed first, by its comparative softness. The finger nail will scratch it slightly. Then there appears a sericitic or talcose constitution. This is seen in the smooth surfaces of some of the joints; and in the soft and easily bruised state of consolidation; and also, in the fibrous nature of some of the jointed surfaces. The color is a pale greenish or bluish drab. Some of the fracture surfaces reveal thin scales partly disengaged, and these are waxy translucent. They pass into the general substance of the rock; and it is apparent that this material constitutes the principal part of the mass. It is softer than feldspar and harder than talc. It approaches calcite. Some of the jointage surfaces have a dark green, shining and chloritic appearance.

This detailed description will not all apply to the rocks not denominated greenstone, so far as seen on this lake; but the general features here described are the same as those designated "sericitic felsyte schist;" and perhaps those called simply "felsyte schist." Special comparison should be made. The description does *not* apply in any particular to the rocks denominated greenstone. Yet, I cannot affirm that these two classes of rocks do *not* graduate into each other. Nor can I affirm that this rock is *not* eruptive, even if it does not go with the greenstones.

If this rock is shown to be eruptive, I shall be willing to admit the chloritic rock at Kawasachong falls to be eruptive also.

While the observations from Saganaga lake southward to Frog Rock lake remain fresh in memory, I wish to make a revision and comparison of data as far as can be done in the field, in order to leave a record of the impression which the facts make upon the mind of an observer passing over the ground. This interval covers the mode of transition from syenite to the Kewatin schists which extend from the region of Vermilion lake. Structurally, the absence of any unconformity is an important fact. Petrographically, the frequent gradual passage from rocks usually called eruptive to rocks retaining distinct traces of sedimentation is a curious, almost an anomalous fact. In order to reach a better comprehension of the latter fact I make a careful comparison of rock specimens. The first result is as follows:

A. The following are nearly identical with each other: 858, 857, 855, 854, 853, 850, 847, 844, 840.

B. The following are similar to class A, but somewhat harder: 856, 848.

C. Like A in groundmass, but with minute shining scales: 845, 844

D Like C, but porphyrelloid: 584, 846, 860, 885.

E. Having a groundmass like A: 843, 837, 836.

F. Haxing the feldspar constituent altered toward a sericitic condition: 841, 838 (approaching class E)

It appears, therefore, disregarding the diabases and greenstones, that a progressive change in the character of the country rock can be traced from sec. 14, 66-5, in Saganaga lake, to the present point. In my uncertainty as to the nature of the prevailing and characterizing mineral—whether parophitic, talcose, serpentinoid or sericitic—I will here call it Kewatin stuff; since it is similar to the mineral which I find generally in Kewatin rocks. (See especially Knife lake, IVth Arm, north and south bifurcations). There is one pause in the passage, and that is to develop the micaceous (Vermilion) phase, at the interval between West Seagull and Frog Rock lakes. Recalling what is recorded in connection with West Seagull lake, rock 593, I will endeavor to note the succession from the Saganaga syenite southward—

1. Saganaga syenite with constituents well isolated.
2. Saganaga syenite or gneiss, quartz elongated, feldspar having a partial groundmass character.
3. Syenite without hornblende.
4. Hornblende wanting, feldspar transitional to Kewatin stuff.

The course is now two-fold.

5 (a). Quartz and *Kewatin* stuff—no feldspar except in porphyrelloid condition.	5 (b). Quartz and *Chloritic* stuff—sometimes feldspar.
6 (a). Crystalline schist, or (b) Kewatin rock.	6 (c). Chlorite schist, or (d) Kewatin rock.
7 (a) Graywacke, or (*b*) Kewatin rock.	7 (c). Graywacke, or (d) Kewatin rock.

All these stages of progress can be traced from Saganaga lake tc place. The syenite indeed reappears south of the lake; but I thi line of travel could be found along which there would be no retrog sion. The reappearance of syenite results probably from the ; that the south border of the syenite is not a straight east and w line, but crosses more than once the line traveled, thus:

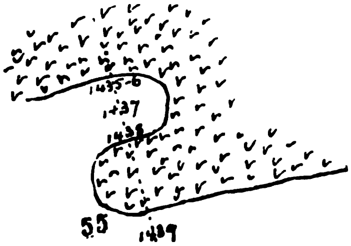


Fig. 55.—*Supposed southern border of Saganaga syenite, three times crossing line of observation.*

Note.—In this figure the numbers refer to rock samples collected as follows:

1435 shows place of rock 835-7.
1436 " " " 838-41.
1438 shows place of 842.
1439 " " 843.

[N. H. W.]

I venture to think, therefore, (1). That we have the crystalline schist stage (Vermilion) from the south part of West Seagull lake to the north part of the portage to Frog Rock lake.

(2). We have the Kewatin stage thence to this point and beyond. The inference is that the rock here is *sedimentary*, and not eruptive; and that therefore, the Kawasachong rock is also *not eruptive.*

(3). The greenstone is an overflow, which perhaps has covered the whole region, and has powerfully altered the underlying Kewatin; but this was probably the northern and thin portion of the sheet; and it has been removed at many points. I should look for it to be thicker toward the south.

West of centre of sec. 16, T. 65-5. N. W. bay of Frog Rock lake. Rock on shore entirely like that of 858. But here a structure can be seen trending east and west. Back of this, a rock bluff rises 40 or 50 feet above the lake, facing south. It presents the same ragged exterior; but fresh-broken, appears more greenish, approaching quite closely the Kawasachong rock.

Rock 859 Chlorite felsyte (schist?)

Another crag 85 or 100 feet high, adjoins this on the east, but it is composed of entirely similar materials. Whatever these rocks are, their equivalent is unquestionably found in the Kewatin of the Vermilion belt.

From this summit, I see high hills 10 or 15 miles distant, bearing S. 60° W. These must be on lake Kekequabic or beyond. Also S. 30° E., a high range which perhaps passes south of Ogishke-muncie. From here eastward, gradually receding, can be seen mountain ranges, extending to S. 60° E.

Rock 860 Porphyrelloid chlorite felsyte (schist?) west of centre of sec. 18, 66–5.

Rock 861. Aphanitic diabase, intersecting the formation.

Rock 862. Less fine diabase, same dike.

S. E. ¼, N. W. ¼, sec. 18, T. 65–5. N. W. cor. of lake. Precisely the same as last two points noted.

N. E. ¼, S. W, ¼, sec. 16, T. 65–5. West side of lake. At this interesting outcrop the formation is a fairly characterized sericitic schist, standing in thin, lenticular laminæ at a dip of 88° in a direction S. 78° E. It is composed of Kewatin stuff, with a few fine grains of quartz, and sinuous films of rusty matter. It presents so many points of resemblance to the prevailing rock that I am sure it goes with the sericitic felsyte schist, and determines that to be a bedded rock of sedimentary origin, as I have conditionally concluded. This is the true continuation of the schists of Vermilion lake; and all the rocks not greenstones and diabases, around this lake, *are to be so reregarded.*

Rock 863. Sericitic schist, with some gravel.

Four rods north of this outcrop, the formation is a little more solid, and the Kewatin stuff is a little greenish, with the same rusty films and spots.

Rock 864. Sericitic schist, near 863.

Eight or ten rods toward the south. Rock with indistinct schistic structure, and having a great resemblance to rock 863; but quite as much resembling the prevailing rock of the region. It is a connecting link between the Kawasachong rock (858) and the sericitic schist of 863.

Rock 865. Sericitic chlorite felsyte.

N. E. ¼, S. W. ¼, sec. 18, T. 65–5. West side of lake. Bluish green rock, similar to prevailing rock, but mostly with a slaty structure. On the whole, a rude slaty structure is quite apparent.

k 866. Bluish argillo-felsitic schist.

k 867. Rock 8 rods farther along the shore, south.

tre S. W. ¼, sec. 18, T. 65-5. Near entrance to most westerly Rock (868) distinctly schistose, a little sericitic, with many h green chloritic points.

int of land S. W. ¼, sec. 18, T. 65-5. A rock of smoother aspect. mostly hard and tough, but also gives indications of argillitic titution. It contains purple spots, mostly undefined, but not as as jasper. There are also *small pebbles* of dark greenstone. Unhe water is an obscure appearance of larger pebbles and broken ments. I conjecture this to be the eastward extension of the *hke conglomerate.*—rock 869.

little farther along (northwest) up the little bay, the conglomeritic acter is more distinct, and I can perceive that the pebbles are egated in courses standing almost vertically. Adjoining this, the has a rough chloritic aspect, entirely conformable in position with onglomerate.

ntre S. W. ¼, sec. 18, T. 65-5. East side little bay. Rock (870) quasi-diabasic aspect, but also with appearance of the country . Considerable argillitic material, and locally a slaty structure.

tremity of little bay, centre S. W. ¼, sec. 18, T. 65-5. Conglom-, with large pebbles of chlorite syenite.

ck 871. Chlorite syenite pebble, from conglomerate.

W. ¼, S. W. ¼, sec. 18. T. 65-5. Point of same bay. Mouth ream coming in at point of little bay. Rock (872) quite distinctly itic and sericitic. The strike is S. 10° W., and it therefore passes of the conglomerate seen near here.

W. ¼, S. W ¼, sec. 18, T. 65-5. Still within little bay. Com-, sericitic-looking rock (873), but not very schistose.

W. ¼, S. W. ¼, sec. 18. T 65-5. Mouth of bay, west side. Blu-compact, but slightly argillitic rock (874).

. W. ¼, S. W. ¼, sec. 18, T. 65-6. Compact, slightly argillitic, but h purplish tints, as if from obliterated pebbles (875).

couple of rods further along (southeast), the rock is softer again, lighter colored. Still, in a couple of rods it becomes undistinishable from that of 858. It is the same at the next outcrop, but fter. The same continues along the southwest shore.

S. W. ¼, S. W. ¼, sec. 18, T. 65-5. A high boss of greenstone-like rock (876) pretty hard and compact, and generally rather fine—in part very fine, h[illegible] and ringing. This appears after an eighth of a mile from th[illegible]rop of schist.

This "greenstone" does not terminate at any particular place along the shore into the southern bay of the lake. It gradually assumes a rougher exterior and a softer character and passes insensibly into a rock like that of 858.

Rock 877. Greenstone passing into chlorite schist.

Rock 878. Greenstone 30 feet from 877, more approximated to chlorite schist.

N. E. ¼, N. W. ¼, sec. 19, T. 65-5. Extreme southern shore Greenstone (879) like that of rock 876.

The same continues along the southern shore of the south bay of the lake.

N. W. ¼, N. E. ¼, sec. 19, T. 65-5. Southeast angle, southern bay.

A cliff near shore which proves to be undoubtedly Kewatin.

Rock 880. Sericitic argillyte.

N. W. ¼, N. E. ¼, sec. 19, T. 65-5. East side of south bay. Greenstone like.

Eight rods further south. Low, smooth outcrop of diabasic rock, greenstone like, with fragments of light green diabase-like rock.

Rock 881. Diabasic conglomerate.

Four rods further north. The rock is more argillitic.

Rock 882. Chloritic argillyte.

S. E. ¼, S E. ¼, sec. 18, T. 65-5. Southeast bay. Sericitic schist (883) irregularly schistose, with strike nearly north and south.

Four rods further north it is a little bluer.

S. E. ¼, S. E. ¼, sec. 18, T. 65-5. Southeast bay. Sericitic argillyte, but becoming bluer and harder.

S. E. ¼, S. E. ¼. sec. 18, T. 65-5. East side. Same as rock 858.

A few rods still farther north. Greenstone.

§ 29.—TOWN LINE LAKE.

A small lake on the line between Ts. 65-5 and 65-6, having a length east and west, of two-thirds of a mile and a mean width of 40 rods. It is utterly destitute of scenic or agricultural interest. The primitive forest is mostly destroyed, but second growth poplars are becoming abundant. Geologically it lies on the transition from the normal Kewatin schist to the conglomerate and associated rock masses surrounding Ogishke-muncie lake.

The portage out of Frog Rock lake to Town Line lake is at the nearest approach of the two and is not over an eighth of a mile long.

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. West end of portage. A knoll of chloritic sericitic schist (884).

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. North side. Incipient porphyrel (885). Some of the weathered surfaces are decidedly speckled.

S. W. ¼, N. W. ¼, sec. 18, T. 65-5. North side near town line.

Ogishke conglomerate pretty well developed. Contains red jasper (886), not as a pebble, and this is banded and associated with hæmatite.

S. W. ¼, N. E. ¼, sec. 13, T. 65-6. West end. Conglomerate, but not coarse, somewhat porphyritic, (887).

S. W. ¼, N E. ¼, sec. 13, T. 65-6. West end. Outcrop of rock composed largely of quartz grains, with sericitic stuff in the interstices (888) Contains also, small pebbles or grains of *slaty material.*

S. E. ¼, N. E. ¼, sec. 13, T. 65-6. South side. A higher outcrop of similar grit (889), but inclining more to a grayish color. Rock quite schistose. Strike S. 20° W. Dip vertical.

Compare the gravelly schists on Ensign lake. Report of 1886, and on Ogishke-muncie lake, below.

S. E. ¼, N. E. ¼, sec 13, T. 65-6. South side of narrows.

The rock is compact, almost wholly of quartz grains, with a light colored cementing material, which becomes pinkish on weathering.

Rock 890. Quartz grit.

S. W. ¼, N. W. ¼, sec. 18, T. 65–5. South side on town line. Porphyrel, as on opposite shore, rock 855.

S. W. ¼, N. W. ¼, sec. 18, T, 65–5. South side. Ragged rock, like rock 858.

A little farther east, it is succeeded by a sericitic rock, like that on Town Line lake, rock 884.

The portage from Town Line lake to Ogishke-muncie is execrable. The bad trail leaves the former lake eight or ten rods north of the stream which comes in with rapids, and leads to the inlet on Ogishke-muncie; but the stream must be forded twice before sufficient water can be reached to float a canoe; or else one must make his way along a steep hill-side through thick brush to reach the spot. The black flies too, as late as the 12th of September, were innumerable and insatiate.

§ 30.—OGISHKE-MUNCIE OR KINGFISHER LAKE.]

This lake was visited in 1886,* and considerable study was bestowed upon it; but it was not much investigated in the region northeast of the narrows in section 23, T. 65–6. The two parties in this part of the State made a rendevous, therefore, on Camper's island, for the purpose, among other objects, of completing the survey.

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* *See Fifteenth Ann Rep* 1886, pp. 156–167.

S. E. ¼, N. W. ¼, sec. 24, T. 65–6. Here is a bluff of crumbling schistic rock (891) forming an earthy talus. It is a sericitic, gritty, irregularly bedded, slate. Strike in the direction of the little bay, N. 40° E.

Adjoining this, on the southeast, within four rods, is a bluff of characteristic, coarse conglomerate. Other ridges succeed southeastward, which are also conglomerate.

The unplatted little lake on the southeast is at least 20 feet above Ogishke-muncie.

N. W. ¼, N. E. ¼, sec. 24, T. 65-6 Here, six or eight rods back from the shore, and separated from it by a narrow valley, rises a ridge 25 feet wide and 20 feet high, from low ground each side, trending southwest and northeast, of a rusted exterior and very rough and brecciated aspect. An unmistabable bedding is present standing in a vertical position. When broken, the rock appears composed of calcareous or dolomitic matter, which, in places, is light colored and characteristic. Everywhere, however, it has an uneven, semi-brecciated structure, and it incloses fragments which are pretty slaty in color and substance. Some of the surfaces of the formation are smooth, sericitic-looking and often argillitic.

Rock 892. Brecciated dolomyte (limestone?)

Following along the strike of the formation southwestward, a few rods, it is seen in places quite argillitic, with a sericitic aspect.

Rock 893. Sericito-argillitic dolomyte.

The ridge on the southeast within eight or ten rods, and rising 20 feet above the dolomyte ridge, is composed of silico-argillaceous material, partly quite solid, and partly laminated and crumbling.

Rock 894. Silico argillaceous slate.

The ridge on the northwest side of the dolomitic one is formed of hard material, breaking in many angular pieces. Under the lens, it appears formed of small spherical grains of quartz imbedded in a groundmass which, in places is very scant, and in others, half the bulk of the rock. It has a felsitic aspect. It is simply Kewatin stuff. I notice also, numerous small siliceous scales. This ridge fronts the lake and is only about 16 rods from the southeast ridge, with the lower, dolomitic ridge between.

Rock 895. Felsitic grit (or argillo-felsitic).

is groundmass is not harder than calcite, and cannot be purely tic. Nearer the lake are good vertical argillytes.

ar this, south of the prolongation of this ridge, I find the rock a h-weathering sericito-argillitic slate, like the bluff, rock 891.

. W. ¼, N. E. ¼, sec 24, T. 65-6. High ridge on lake border, hav- a vertical, slaty structure, except in places, where it *looks* erupt- It is composed mostly of argillitic material, but contains many ns of quartz

ock 896. Gritty argillyte.

places. the formation contains large pebbles, and the interven- groundmass weathers white, and reveals a distinctly fibrous cture. In the same places, the fresh-broken surfaces scarcely al the existence of pebbles.

. W. ¼, N. E. ¼, sec. 24, T. 65–6. The next ridge southeast of 896, composed of very hard, diabasic-looking material *which ains pebbles.*

ock 897. Matrix of diabasic conglomerate.

long side of this, however, and eight feet lower, a distinctly slaty k outcrops (898), having a sericitic-argillaceous aspect—and the graduate together.

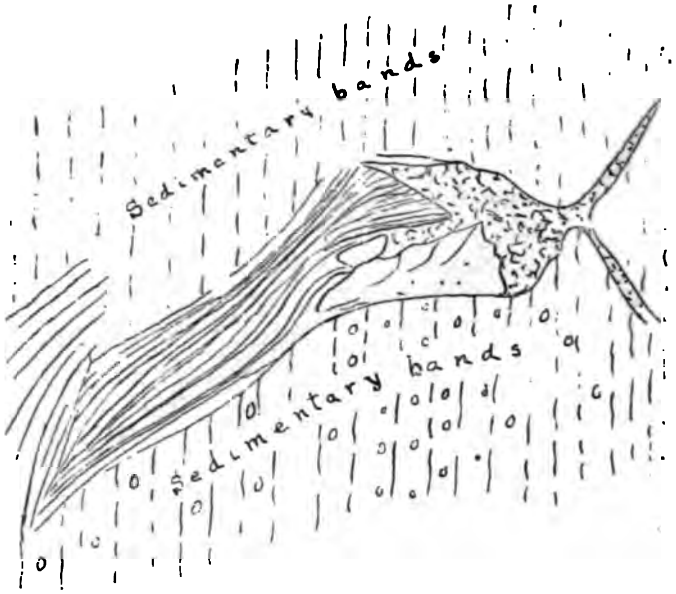
Next higher ridge ten rods southeast. Indistinctly conglomerate, h groundmass containing many dark green grains and lumps, some rtz particles, and much argillo-felsitic matter.

Rock 899. Argillo-felsitic groundmass.

The highest hill about one-fourth mile back from the lake. The mation is thoroughly conglomerate, but very compact and frequent- hard—sometimes ringing. A few rods further southeast, the form- on reveals a structure which is sedimentary beyond possible ques- n. Parallel bands of graywackenitic material can be traced for 30 t in a direction N. 20° W. In the same place, other structure lines n be seen, bending around what appear to have been separate masses the same rock.

The surface of the rock is studded with spheroidal concretions (900), ich have been cut in section and have hollow centers apparently the solution of the interior portion. They are not pebbles, for y are all very similar, and besides, reveal, in some cases, concen- c lines. See the figure.

In a neighboring spot, the strike of the beds is quite different, and ere are concomitant indications that these portions of the formation simply huge fragments of the general mass, which were displaced ring the deposition of the original sediments.



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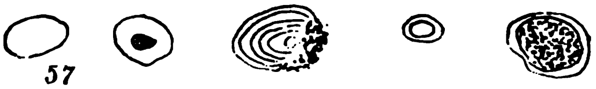

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Fig. 56.—*Rock surface in Ogishke conglomerate, showing sedimentary structure.*

Fig. 57.—*Spheroidal concretions in matrix of Ogishke-conglomerate.*

In further tracing these stratified materials, I find in one place a continuous sweep through about 85° of a circle. This is fifteen feet wide, and the circuit is about forty feet.

§ 31.—CRAB LAKE.

This is a small lake lying in the north half of sec. 14, T. 65-6, environed by a lonely and desolate wilderness and set in a massive rim of graywackenitic and slaty rocks, rising in frequent dark-weathered and rounded bosses. Guided by the government plat, I entered from the most northern extremity of Ogishke-muncie lake, supposing there would be a portage of a few rods; but it proved to be about half a mile, without the least signs of a trail. There is a low valley running through, densely grown with alders and other shrubs. On the north of this is a high ledge, difficult to climb. But the best transit is made by leaving the valley and working along on the ledge; and it is finally necessary to cross the west end of the ledge, to descend to the lake.

The fact is, the lake begins at least a quarter of a mile west of the point indicated on the plat.

The government plat of this lake is so erroneous that I undertook to reconstruct it. I find, however, that some of my memoranda are ambiguous; and I therefore refrain from making alterations except in the southeastern part. The northern portion, however, is egregiously wrong.

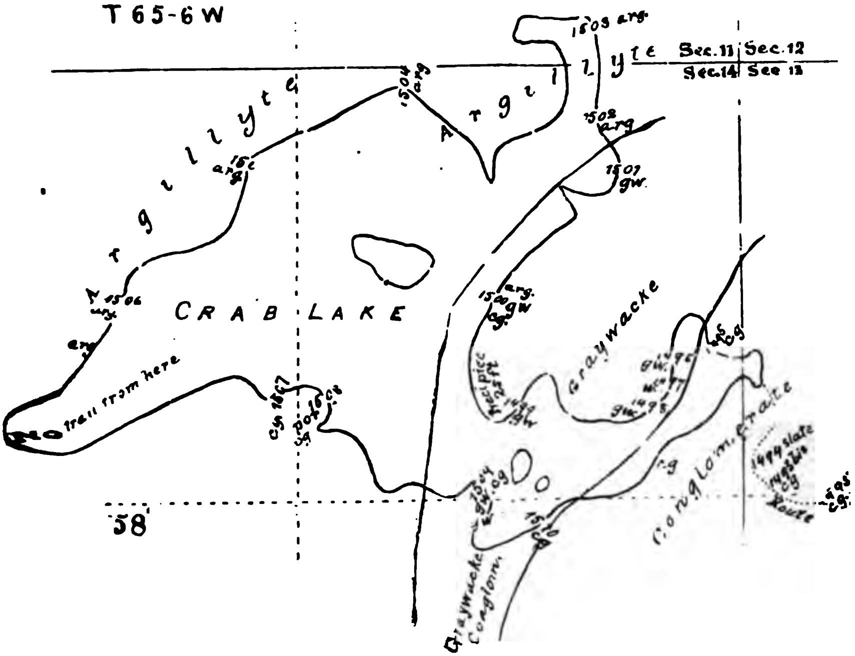

Fig. 58.—*Sketch-map of Crab lake, with notes of localities and geology.*

NOTE.—On the above map.

No. 1493	indicates the locality for rock	901-3.
" 1493 bis	" "	904.
" 1494	" "	905.
" 1495	" "	906.
" 1496	" "	907.
" 1499	" "	908.
" 1500	" "	909.
" 1502	" "	910.
" 1503	" "	911.
" 1504	" "	912.
" 1506	" "	913.
" 1507	" "	914.
" 1508	" "	915.

N. H. W.

N. W. ¼, sec. 13, T. 65 6. On the portage. High precipice north of the stream flowing from Crab lake to Ogishke-muncie. Here are various conditions of the conglomerate.

Rock 901. Conglomerate.

Rock 902. Porphyrel.

Rock 903. Matrix showing bedding lines.

Fifteen rods farther west, same ridge. Conglomerate, with large quartz grains.

Rock 904. Porphyritically quartzose conglomerate.

S. W. ¼, N. W. ¼, sec. 13, T. 65-6. Same ridge. 30 rods farther west The formation has become a thin-bedded slate, but with some strata massive and finely arenaceous.

Rock 905. Argillyte, somewhat arenaceous.

S. E. ¼ N. E. ¼, sec. 14. T. 65-6. Near east end of lake, north side, conglomerate, but fine, gritty, and not characteristic.

Rock 906. Fine gritty conglomerate.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6 Gritty graywacke, with horizontal bedding, but evidently superinduced.

S. E. ¼, N. E. ¼, sec. 14, T. 65-6. Graywacke (907), not gritty, weathering with a cellular surface.

S. E ¼, N. E. ¼, sec. 14, T. 65-6. Great bosses of graywacke

S W ¼, N. E. ¼. sec. 14, T. 65-6. Great mass of graywacke (908), without trace of bedding, like rock 907, but with many minute glistening feldspar surfaces.

This is followed by a very bold cliff standing vertically, and rising 35 feet above the lake. This subsides as we round the promontory, and for a few rods, no outcrop occurs.

S. W. ¼. N E. ¼. sec. 14. T. 66-5. Mostly graywacke, but sparingly conglomeritic.

Rock 909. Graywacke or groundmass.

Then succeeds another cliff 25 feet high, of graywacke, continuing to next locality.

N. E. ¼, N. E ¼. sec. 14. T 65-6. Graywacke.

A low marshy place appears, at nearly the most northern arm of the lake.

N E. ¼. N. E. ¼, sec. 14, T. 65 6. Argillyte fairly characterized.

Rock 910. Argillyte with crystals of feldspar.

S. E. ¼. S. E. ¼, sec. 11, T. 65-6. Compact argillyte (911), irregularly slaty.

N. W. ¼, N. E ¼. sec 14, T. 65 6. Characteristic dark gray argillyte (912), slaty.

N. E. ¼, N. W. ¼, sec. 14, T. 65-6. Regular Knife lake argillyte.

S. E. ¼, N. W. ¼, sec. 14, T. 65-6. Characteristic slaty argillyte (913).

S. E. ¼, N. W. ¼, sec. 14, T. 65-6. Conglomerate (914), but the pebbles are mostly quartzose and cherty—a few of dark flint.

As before, when the pebbles are small, many of them are subangular.

S. W. ¼, N. E. ¼, sec. 14, T. 65-6. Rock approaches the graywackenitic groundmass material seen on the north shore of the lake; but it is manifestly conglomeritic, and contains also crystals of a light feldspar. Except this, it is similar to rock 906, but finer.

Obscurely porphyrelloid, graywackenitic conglomerate.

S. W. ¼, N. E. ¼, sec 14, T. 65-6. Graywackenitic matrix of conglomerate. Similar rock continues eastward along the southern shore.

N. E. ¼, S. E. ¼. sec. 14, T. 65-6. Conglomerate. Graywackenitic conglomerate continues to the place of beginning.

§ 32 —ZETA LAKE.

This small lake, lying wholly in sec 28, T. 65-6, is partly described in the Report of 1886.* A few additional notices are here given. It has two portages eastward—one on the south into Dike lake and thence into Ogishke-muncie; and one on the north directly into Ogishke-muncie. As the former was traveled by me last year, I chose now the latter. It goes out of Ogishke-muncie south of the point shown on the plat. It is a quarter of a mile long, and very bad, over rocks and through a swamp. The northeastern part of Zeta lake exists only on the plat. The lake comes to a point in the S. W. ¼, N. W. ¼, sec 27, T. 65-6.

S. W. ¼, N. W. ¼, sec. 27, T. 65-6. East end of portage from Ogishke-muncie. Characteristic conglomerate.

S. W. ¼, N. W. ¼, sec. 27, T. 65–6. West of same portage, Zeta lake. Conglomerate.

Rock 916. Conglomerate with pebble of the most abundant kind. It is a porphyritic rock in this case, with a feldspathic groundmass. But the groundmass (917) of the conglomerate itself tends to be porphyritic.

§ 33.— EPSILON LAKE.

Epsilon lake was partially seen by me in 1886.* It is a mile and a quarter in length with a mean breadth of a quarter of a mile, and bent arcuately in secs. 29, 20 and 21, T. 65–6, having the convexity turned northward. It is bounded by rocky knolls and ridges on the north, east and southeastern shores. The south shore is forest covered and no exposures of rock appear on it; but half a mile back is a range reaching an elevation of 125 feet or more. From the range on the north we look down on the Fourth Arm of Knife lake 250 feet below, and 190 feet below Epsilon lake. We approach this lake from Zeta lake, through a steep and rocky defile with a descent of 75 feet, and find a portage out on the north into Knife lake by a descent of about 90 feet.

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*Fifteenth Ann. Rep. Minn. Geol Surv., pp. 156, 158-9.

N. E. ¼, N. W. ¼, sec. 28, T. 65–6. At the foot of the descent from Zeta lake. A precipice of dark argillyte rises on the east. The rock is entirely free from pebbles, and very characteristic. The strike is N. 30" E., and the dip is S. 75°. But I notice on the sides of the sheets, as in the Kewatin of Gunflint lake, some striations, or a fibrous structure dipping 54° W. The dip is such that *the Ogishke conglomerate is overlying.*

S. E. ¼, S. W. ¼, sec. 21, T. 65–6. Bold promontory northeast side of lake. Slates varying from vertical to steep southeast dip. In structure ranging from proper slaty to fissile-slaty, and weathering somewhat like Kawasachong rock — but not chloritic.

N. E. ¼, S. W. ¼, sec. 21, T. 65–6. Southwest angle of same promontory. Argillyte, which on shore dips north at an angle of about 50°, but on the summit of the hill back, which I ascended, dips S. at an angle of 67°, and strikes N. 35° E. So it appears that a large mass at the point of the hill has been dislocated.

I notice here some bands running across the faces of the laminæ, which dip westward at an angle of 14°.

Rock 918 Argillyte with the banding spoken of above.

Examining further, I find these bands are the outcrop of sedimentary planes on the surfaces of the schistic plates. They show the real dip of the sedimentation, which here is S. 60°.

Re-examining the dip at the point of the hill, I find it about 50° toward southwest, and to exist in the true sedimentary bedding. I still think, however, that this mass is displaced.

Rock 919. Argillyte with sedimentary banding passing at right angles through the schistic laminæ.

N. E. ¼, S. W. ¼, sec 21, T. 65-6. West base of same promontory. Slate bluff with *bedding structure dipping* 23° *toward S.* 40° *W. The schistic planes stand vertical.*

N. W. ¼, S. W. ¼, sec. 21. T. 65-6. North side of lake east of portage. Slate (920), but more ancient looking than what I saw at the west base of the promontory. The schistosity runs as usual; but there are no separate bedding planes. *These appear to conform with the schistosity.* The rock looks exactly like the Kewatin of Gunflint lake.

The suggestion arises that we have here slates of *two different systems*; the upper of which are Animike. But since the schistosity is the same in both, the action which caused the schistosity was a post-Animike one, and was felt here, but not as far east as Gunflint lake. But there must also have been a pre-Animike squeezing. Even at Gunflint lake the Kewatin is squeezed vertically, while the Animike is almost undisturbed.

These slates in weathering, slide down the high hill with a decidedly sericitic habit and aspect.

N. W. ¼, S. W. ¼, sec. 21, T. 65-6. North side Epsilon lake. Finding the formation so different, I went back to find the junction of the two. It occurs here. On the south is the southward bedded slate (921) with vertical schistosity. On the north is rough, older-looking slate, with vertical schistosity, and no grain or ribbons of bedding in discordance with the schistosity. After considerable search, however, I found structure lines *conformable with the schistosity*, and giving evidence of sedimentary character.

Rock 922. Slate showing discordance between schistosity and sedimentary bedding.

The bedding on the south side dips S. 43°. It is a good ordinary argillyte. The other rock is less regular in its slatiness. The two outcrops are separate bosses ten feet apart; but it would not have been difficult with a pick and spade, to trace the formations into actual contact. The situation is this:

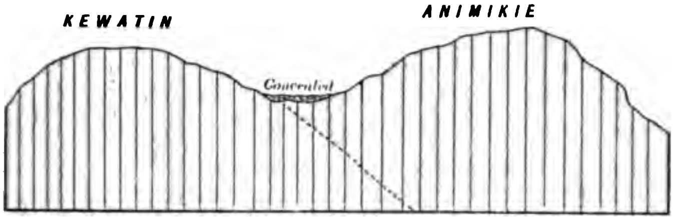

Fig. 59.—*Contact of Kewatin and Animike systems north side of Epsilon lake.*

N. W. ¼, S. E. ¼, sec. 20, T. 65-6. Ridge west of portage entrance.

The formation of this ridge is Kewatin; and it is a prolongation westward of the high ridge, rock 920; while rocks 920 and 921 are from the eastward prolongation of the same, with some additional beds on the south. I find the bedding structure (923) here corresponds with the schistic.

N. E. ¼, S. W. ¼, sec. 20, T. 65-6. Continuation of same ridge one-fifth mile further west. Slates near shore; but poroditic slaty and porphyrelloid farther back on the summit of the 80-foot hill.

Rock 924. Slate showing bedded and schistic structures conformable.

Rock 925. Poroditic porphyrelloid slate.

S. W. ¼, S. E. ¼, sec 20, T. 65-6. Northwest shore of lake. More argillitic — slaty, but the structures are the same. Kewatin slate continues along the remainder of the north and west sides of the lake.

A casual observation of the south shore of the lake indicated no important exposures; but it is to be regretted that a more careful examination was not made, since it seems probable some trace of Animike schists, southward-dipping, might have been discovered. The formation at the outlet of Delta lake, was observed last year and reported "fine hard argillyte, rather slaty." It is so near the point above described at the foot of the descent from Zeta lake that probably the formation is the same. Similar Argillitic slates were observed in places all the way from Kekequabic lake and no discordance was noted between schistosity and bedding; but it would be well to re-examine the exposures.

From the west part of Epsilon lake I noticed at the distance of a mile or so, southwesterly, a high peak. Thinking I might find there a cliff of Animike slates crowned with gabbro I determined to visit it.

S. E. ¼, N. W. ¼, sec. 29, T. 65-6. Near south extremity of lake. Pulpit Rock. Ten rods back from the lake rises a sheer vertical rock of 25 feet above the lake, cut down on all sides by smooth vertical planes. It is some sort of greenstone, and has a decidedly greenish color and sub-granular texture, soft and chlorite-like, with needles and amygdules of calcite — rock 926, noryte?

On the south, at the distance of twenty feet, this eruptive mass comes in contact with porphyry But the junction is not abrupt. There are interbedded alternations of the noryte and porphyry, as if both were sedimentary; but these alternations are not repeated many times. The porphyry has a purplish base and lamellar crystals. The following alternations were seen:

Porphyry. | Noryte. | Porphyry. | N. | P. | Noryte. |

Rock 927. Noryte and porphyry in contact.

Rock 928. Fragments of porphyry in modified noryte.

Proceeding southward a quarter of a mile, the porphyry continues. It is a handsome rock.

Rock 929. Specimens of purple porphyry.

S. E. ¼, N. W. ¼, sec 29, T. 65-6. South of west end of Epsilon lake. High, prominent mass of porphyry, presenting characters of an eruptive formation. The porphyry contains now fewer crystals and is replete with green amygdules.

In our progress south, I found apparently a lost, but large piece of iron jaspilyte handsomely banded. The following is the plan of structure and coloration.

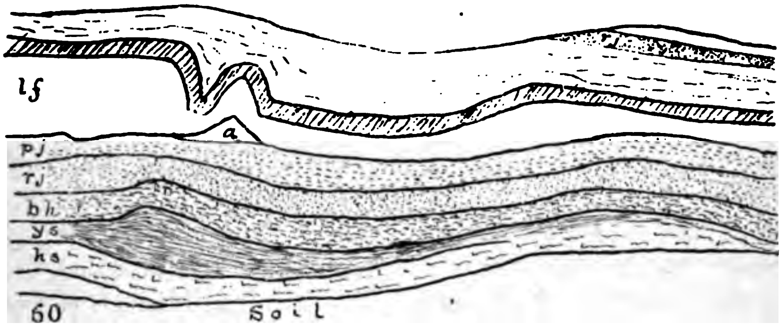

Fig. 60.—*Banded hæmatitic jaspilyte, Epsilon and Kekequabic lakes.* Not in place.

rj. red jasper.
pj. purple jasper.
lf. light flint.
bh, black hæmatite.
hs., hæmatitic schist.
ys, yellow schist.

This bears a close resemblance to jaspilitic schists heretofore found in the vertical Kewatin slates. (See p. 197, in this Report, and many observations west of Knife lake).

S. E. ¼. N. W. ¼, sec. 29, T. 65-6. Nearly midway between Epsilon and Kekequabic lakes. The porphyry has increased in amount of green amygdular mineral, until on a fresh surface, it begins to resemble the noryte; but still differs by the presence of a groundmass of whitish color, and weathering quite white.

Rock 930. Porphyritic greenstone.

Rock 931. Fragment of Kewatin showing two structures.

At a point near the base of the high bluff, the porphyry shows flowage lines as illustrated below.

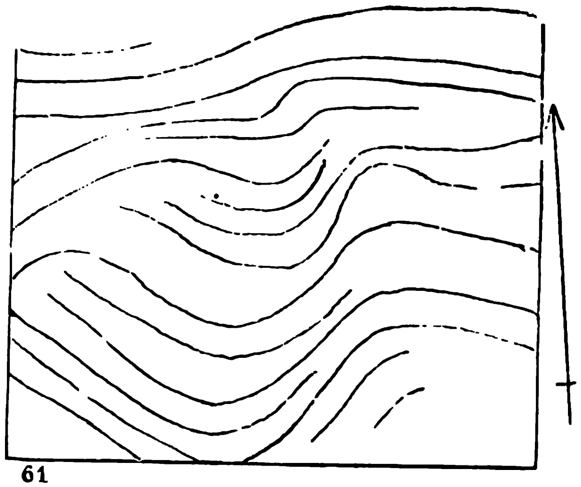

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Fig. 61.—*Structure lines in porphyry, near Grant's peak.*

N. E. ¼, S. E. ¼, sec. 29, T. 65-6. Summit of Grant's peak. This is a high and sightly place about midway between lakes Kekequabic and Epsilon. From here I see the west end of the Kekequabic, Alpha and Beta lakes, much of Epsilon and all the IVth Arm of Knife except the eastern half of the two terminal branches. I see the Twin mountains, Mallman's peak and Prospect peak south of Ogishke-muncie lake. This peak I name in recognition of the valuable services of a most faithfuth assistant, Uly. S. Grant, of Minneapolis.

This peak is about 200 feet high, and presents on the eastern aspect, a perpendicular precipice of 100 feet.

The following are some bearings from Grant's peak:

Mallmann's peak, S. 42° W.

East Twin mountain, S. 56° E.

West Twin mountain, S. 36° E.

Prospect mountain and middle of Beta lake, east.

Entrance North Branch, IV Arm Knife lake N. 10° E.

These bearings are in harmony with the locations of points on the plat, except that of Prospect mountain; and I think perhaps some summit east of Fox lake was mistaken for Prospect mountain.

Grant's peak seems to be a mass of purple porphyry of a truly eruptive character.

Rock 932. Purple amygdaloidal porphyry, Grant's peak.

The numerous other hills east, west and south, for the distance of half a mile, appear also like similar, rounded bosses of porphyry.

After returning from a tour of half a mile and back, over this purple porphyry, I am not possessed of a full conviction of its truly eruptive character. I find many structure-lines which conform to the stratification of the surrounding country. It has of course been in a highly softened condition, and in that state has been moved.

Rock 933. Varieties of the purple porphyry, Grant's peak.

§ 34.—GARDEN LAKE.

On the return to Vermilion lake, my brother and I determined to re-examine some points on and near Garden lake; and especially the abandoned iron location marked on the plat as "Silver City"—an absurd designation which ought to fall into disuse. This region was examined by both of us in 1886;* but we had just returned from very extended observations of iron-occurrences in the Animike slates, and it was desirable to ascertain whether this experience would modify the determination recorded last year. I think I may say those determinations were not changed.

On the portage from Fall lake to Garden lake. A trench has been extended east and west on both sides of the upper portage, and iron-jasper exposed most of the distance; but in walking along it I saw no good ore.

Near Silver City. A quartzyte (or rather quartz schist), standing vertical, and striking east and west, interlaminated with green chloritic matter, in which are imbedded octahedrons of magnetite. Needle is here reversed.

Rock 980. Quartzyte and magnetite.

Within two rods of the excavation is an exposure of siliceous slate, thin-bedded and dipping 74° N. 60° W. This certainly has quite an Animike aspect.

Rock 981. Magnetitic siliceous slate.

Passing along beyond the excavation, we find interbandings of magnetitic quartz-schist and something appearing like incipient mica schist. Also sericitic or brownish quartz-schist (981) and dark quartz-schist.

Farther on, mica schist becomes still more developed; but the magnetitic quartz-schist prevails.

Rock 983. Mica schist and magnetitic quartz-schist.

Sometimes the mica schist is interbanded with chlorite schist similar to that containing octahedrons of magnetite.

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* Reported on in *Fifteenth Ann. Rep. Geol. Surv. Minn.*, pp. 67-73, 329.

Rock 984. Mica schist and chlorite schist.

Rock 985. Hornblende schist associated with above.

These observations extend to the rapids out of White Iron lake. I ascertained last year that syenitic gneiss makes its appearance near the head of the rapids. The group of strata just mentioned, therefore, must be regarded as exemplifying the usual transition from the earthy (Kewatin) schists to the truly crystalline schists and gneisses. The peculiarity of this region is the repletion of the schists with hæmatite and magnetite. Their conformability, however, with the entire system of schists — earthy and crystalline — and their close stratigraphic proximity to the gneisses, preclude the admission of the existence here of a super-Kewatin formation.

N. E. ¼, S. E. ¼, sec. 28, T. 63–11. Garden lake. Low outcrop which seems to be on the dividing line between sericitic schist (very porphyrellyte-looking) and mica schist. I preserved specimens in two stages.

Rock 986. More porphyrellitic,

Rock 987. More micaceous.

These additional observations illustrate the genesis of mica and hornblende out of the common material characterizing the Kewatin slates, and which for convenience I have called Kewatin stuff.

At Tower, at the end of the season, the iron mines were revisited.

Stone iron mine. A structure bearing some resemblance to a dike existed here last year,* but at the present time, the disintegration of the south wall has almost completely removed the portion taken for a dike, and dispelled all possible illusion.

Vermilion Iron Mines. The rapid decay of the sericitic schist under the influence of the weather, is shown in the large quantities of crumbling schist and white powder (988) formed in an open and unworked excavation.

It is to be ascertained why the crumbling is so much more complete here and the color so much whiter than in ordinary exposures of the sericitic schists.

From an opening for iron about five miles southeast of Tower, I was handed the following specimens:

Rock 989. Fine banded quartzyte (quartz-schist) associated with iron ore.

Rock 990. Graphite, from the above opening.

This association reminds one of observations recorded above at the old working known as Silver city. The opening from which they were obtained is about 20 miles in a right line from the head of Garden lake; but both localities lie very nearly on the belt of the "Vermilion group" of crystalline schists.

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* Described in *Fifteenth Ann. Rep. Geol. Surv. Minn* pp. 24, 231–6.

§ 35.—GENERAL SUMMARY OF FACTS OBSERVED.

The details of observation recorded on the preceding pages possess a high degree of geologic interest. These, with the details published in 1886, furnish the means for arriving at an improved conception of the nature, age and relations of some of the oldest systems of rocks known to the geologist, and called collectively Archæan or Azoic. In most other sections of the country presenting Archæan rocks at the surface, we find them so greatly and so irregularly disturbed, that extreme difficulty arises in the attempt to make out a complete order of superposition. For this reason, geologists have been widely at variance in the views presented. Generally, we have acquiesced, in a provisional way, in the judgment reached, some years since, by the Canadian geological survey that the entire series of pre-palæozoic strata consists of two divisions, known as the Laurentian system below, and the Huronian, above. Some, however, have recognized three, four or five systemic divisions. Even Sir William Logan was inclined to make two systems of the Laurentian. On the other hand, others have failed to see the grounds for any systemic divisions of the Archæan rocks; and have maintained that it is unwise to attempt a division of them until their characters and relations should be more completely understood. Divergence of opinion has been so wide, and recorded conclusions so uncertain, that within a few years the summary judgment has been pronounced that "our chances of having at some future time a clear understanding of the geological situation of northeastern North America would be decidedly improved if all that has been written about it were at once struck out of existence."*

These statements are made to illustrate the extreme difficulty of the investigation of the Archæan rocks in the regions hitherto studied; and to emphasize the importance of careful and competent observations in a region where the Archæan series, as in northeastern Minnesota, has escaped most of those physical disturbances which have involved other districts in confusion almost inextricable. After the abundant details of facts accumulated during two seasons, upon the Archæan rocks of Minnesota, a report might well be regarded incomplete without a concise summary of the general nature of the facts, and a brief indication of the inferences which they seem to sustain. In this place however, the reader will not anticipate any exhaustive discussions. What I have to offer in this conclusion will be more in the nature of a syllabus of the full discussion of which the facts recorded might serve as a basis

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* Whitney and Wadsworth: *The Azoic System and its proposed subdivisions.* Bull. Mus. Comp. Zool. Geol. Series, I, 520.

All the clastic rocks in the northeastern angle of Minnesota, omitting here all reference to the red sandstone, present an ancient, prepalæozoic aspect. Associated with them are eruptives of various sorts, which probably rose to the surface at very diverse epochs. The clastic rocks are destitute of fossil remains, as far as known. Most of them have been subjected to metamorphic actions; and to a large extent, these have been intense. Enormous masses have assumed a condition fully crystalline.

Within the region here considered, the geographical distribution of the several terranes is east-northeast in the Vermilion district, and nearly east in the district eastward from Knife lake. Throughout the entire region, the clastic rocks—not excluding the so-called granites and syenites—present a bedded structure, sometimes indeed obscure, but everywhere discernible over all considerable exposures. Among the granites and gneisses the bedding may possibly be regarded as the result of foliation alone; but I have been led to think that its direction was predetermined by planes of sedimentation. This question however, at an appropriate time, will receive special consideration. For similar reasons, I regard the bedding of the crystalline schists as primitively sedimentary. The two older systems of rocks have their planes of bedding nearly vertical—inclining only a few degrees in one direction or the other. The bedding of the newer system is nearly horizontal—inclining five to fifteen degrees southward in the regions here reported on.

1.—*Granitoid and gneissoid rocks.* Within the district under consideration, occur three areas of granite or granitoid gneiss, which I will here designate 1.—The Basswood granite, 2.—The White Iron granite, and 3.—The Saganaga granite. The names are taken from lakes lying within these areas respectively. The former two were described, as far as the writer's personal observations extended, in the 15th annual report (1886). The Basswood granite occupies all the Minnesota shores of Basswood lake, except the southwestern shore of Arm I. The shores of Arm V have been but partially explored, but that arm lies wholly within the granitic field as traced out. From Basswood lake the southern border of this area extends west-southwest to Burntside lake, bringing all except the southwest bay and southern shore of that lake within the granitic area. In my own examinations I have not traced this boundary further west, but it is known to strike Vermilion lake in such a way that most of the northern shore lies within the granitic area. From Basswood lake I have traced this granitic mass along the national boundary to the middle of Iron lake. Other researches show that the entire region between Vermilion and Burntside lakes and the national boundary is occupied by an unbroken extension of the Basswood granite.

The White-Iron granite occupies all the shores of White Iron lake, except those of the northern extremity. Eastward from this, its northern boundary runs a little south and then a little north of the Kawishiwi river, and thence to the western side of Snowbank lake. All except a part of the northwest shore of this lake lies within the White Iron granite area. Farther east, this granitic mass is lost beneath a vast sheet of gabbro. This gabbro covering extends in the same direction as far as lake Gabimichigama, and apparently beyond. To the south of the northern boundary of the White Iron granite as thus traced, this granitic mass has not been explored by the writer, except on the shore of the lake, and at the point where it crosses the railroad between Two Harbors and Tower.

The Saganaga granite occupies all the shores and islands of the lake of that name, except the northwest shore. It does not include Oak lake; but Red-rock, West Seagull, Seagull, Granite and Pine lakes lie wholly within it. On the south it extends to Gunflint falls of the Boundary river, and its southern border has been traced east by north into Canada, along a line about a mile north of Gunflint lake, reaching the shore at the rapids of Gunflint river, and continuing half a mile north of the most projecting bays of North lake. From the western limit east of Oak lake, and west of West Seagull, the Saganaga mass trends into Canada in a mean direction east by north.

It will be noticed that the Saganaga granite lies in the direction of the prolongation of the White Iron granite; but the two are not in continuity at the surface. All the shores of Ima lake, five miles east of Snowbank, are bordered by gabbro, and this rock has been traced northward to Kekequabic, around whose shores the earthy schists are found in place. Thus the whole breadth of the belt of White Iron granite traced from the west, is cut off at the surface and concealed. A little further east, in the mountain range south from Ogishkemuncie lake, a different eruptive, apparently more recent, occupies the surface. About Gabimichigama, the surface is held again by gabbro which extends eastward indefinitely. But in the fifth range of townships west, quite another terrane — the Animike — is seen emerging from beneath the gabbro. This, without attaining here any considerable breadth on the north of the gabbro limit, is found thinning out against the southward slopes of the Saganaga granite. As a fact of surface observation therefore, the Saganaga area is completely isolated from the White Iron area. So far as the facts thus stated go, it seems probable that the two must be regarded as continuous underneath the covering of more recent terranes — the Animike, the gabbro and the greenstone. This view is sustained by the continuity of trend of the neighboring vertical schists through the basin of Knife lake and its long-extended Fourth Arm. It is further evinced by the similar constitution and structure of the Saganaga and White Iron granites. But the separateness is indicated on other grounds to which I shall refer, and my conclusion is that the White Iron and Saganaga granites have only a deep-seated connection.

As repeatedly illustrated in the details of observations reported, these granitic masses exhibit everywhere a vertically bedded structure. This is generally somewhat distinct, and the terrane is a characteristic gneiss. The bedding is most distinct in the neighborhood of the crystalline schists which everywhere flank the granitoid masses. It grows less distinct as we recede from their neighborhood. The nearest approach to the massive condition of a typical granite is noticed along the shores of Crooked and Iron lakes, at a distance of about 18 miles from the schists of Burntside lake. But even in Iron lake the bedding in many places, is quite unmistakable. This bedding, it is almost needless to say, is the usual schistosity of the crystalline rocks.

Bedding of a different sort is occasionally met. The terrane is divided by numerous planes nearly horizontal. At times resulting layers are less than half an inch in thickness; generally, they exceed an inch. The dividing planes do not possess the regularity and rigidity of proper joints, and their cause appears to be extremely different. Slow weathering seems to be indicated by the usual relation of the bedding planes to surfaces of exposure. The most striking examples of this structure occur on the northern shores of Basswood lake, in range nine west.

The characteristic mineral contents of the granitoid rocks are quartz, orthoclase and hornblende or mica. These constituents vary greatly in relative proportions. In the Basswood granite, the quartz grains are generally not over a tenth of an inch in diameter. In the White Iron Granite, they occasionally attain a diameter of a quarter or third of an inch, and in the Saganaga Granite, large grains of quartz are generally dispersed, and become a characteristic feature of that terrane, very often reaching half an inch in diameter. The dark mineral of the Basswood granite is very generally mica—for the greater part biotite, but often hydromica. Muscovite prevails along Crooked and Iron lakes, and biotite and hydromica at Burntside lake. In certain conditions of the formation, the biotite is extremely fine, badly characterized, even under the lens, and seems to be in a nascent state. From such a condition of the rock we pass in one direction, to a well defined mica-granite, and in the opposite, to a well defined hornblende-granite. The transition is transverse to the axis of the bedding. In the White Iron and Saganaga masses, the dark mineral is chiefly hornblende. But not unfrequently it is augite, and very commonly the mineral has reached by the process of change, an earthy and viriditic aspect. In the Baswood area in the vicinity of Pipestone falls, a chloritic mineral usurps the place of mica or hornblende, and instead of occurring in distinct grains or individuals, blends off on the borders into the contiguous feldspar. This condition of the granite is found also in the southern part of lake Kekequabic, and again in the southern part of West Seagull and Seagull lakes, and in the west one of the long Arms of Saganaga lake. Quartz, in these cases, occurs but sparingly. Chlorite-syenite is a condition appertaining to the vicinity of the schists which flank the granitoid masses on both sides.

As to the feldspathic constituent, it is prevailingly orthoclase. This on fresh fracture is white in some districts and red in others. In some regions, the white or pale orthoclase weathers red. This is the case along the shores of Crooked lake, where the wide-extended, bare surfaces acquire a blood-red hue. In other regions, as along the west side of West Seagull lake, the white orthoclase weathers white, and the granitic hills gleam with a brilliance almost dazzling At some places on White Iron lake the orthoclase occurs in individuals an inch in diameter. In other regions, the orthoclase is badly individualized, and forms an imperfect groundmass for the other minerals. Beside orthoclase, triclinic feldspars are generally present in subordinate proportions. Occasionally, by the adventitious absence of the dark minerals, the rock becomes a true granulyte, but generally with an excess of orthoclase. On the contrary, the granulyte is eminently quartzose at the head of the small bay near the west end of lake Saganaga.

The physical structure and mineral constitution of the granitoid masses are subject to marked and sometimes abrupt variations. In the middle of lake Saganaga, I found an island composed of good mica-gneiss. On all sides the formation is syenite. In the westerly one of the two long arms of Saganaga lake, the syenite on one of the islands becomes abruptly quartzose to excess, and simultaneously the orthoclase becomes a feldspathic matrix, and then nearly disappears, and an argillaceous, sericitic, schistic rock takes the place of the syenite. But this is immediately succeeded, on the nearest island, by the ordinary syenite of the region.

A highly striking and significant feature of the Saganaga and White Iron syenites is the presence of rounded pebbles sparingly disseminated, but at certain points aggregated in such numbers as to form a real conglomerate in the midst of the syenite. Many particulars of these occurrences have been recorded in my notes on Seagull, West Seagull and Saganaga lakes, to which reference may be made.

These observations are quite analogous to others made in New England and reported in a comprehensive way in the Geology of Vermont.* In most of the instances cited by Dr. E. Hitchcock, the pebbles are embraced in "talcose schists;" but he mentions cases in Massachusetts and Vermont, of which he says: "We define this rock as a conglomerate with a cement of syenite or granite, or as a syenite or granite with pebbles in it, sometimes thickly and sometimes sparsely disseminated." The rounded pebbles on Ascuteny are "black rounded masses which are for the most part, crystalline hornblende with some feldspar." "At Granby, the pebbles, manifestly rounded, are either mica schist or white, almost hyaline quartz." On the other hand, the pebbles occurring in the Saganaga syenite are mostly greenish, lamellar, augitic and chloritic; but some of them are composed of augite and a feldspar having the microscopic appearance of orthoclase. Quartz is conspicuously absent. To the interpretation of these facts I will briefly return in another connection.

The gneiss and granites are extensively traversed by quartzose and granulitic veins. These have been fully illustrated in the annual report. Dikes of diabase are abundant. Occasionally, as in Burntside lake, they appear to be rather dioritic.

2. *Vermilion crystalline schists.* The vertically schistose gneisses are flanked by vertical crystalline schists having a variable width. These have been designated by the geological survey of Minnesota, "The Vermilion group." Along the south side of the Basswood granite, they occupy an average width of half a mile — but varying from a quarter of a mile to two miles. The belt has been traced quite distinctly from Vermilion lake to near Carp lake — taking in the south shore of Burntside, passing north of Long, including the north part

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* Volume I, pp. 28-45; especially pp. 40 and 41.

f Newton, occupying the west side of Arm II of Basswood lake, the outhern swell of Arm III, and the southern extremity of Arm I. The continuance of this belt of crystalline schists has not been observed further east. It is supposed to strike northeasterly into Canada, lying somewhat to the north of Sucker and Pseudo-messer lakes.

Another belt of the crystalline schists extends along the north flank of the White Iron granite. It touches the northern extremity of White Iron lake, and is well exposed at the rapids out of the lake. Its westward continuation I have not traced. Eastward I have not been able to trace it continuously farther than the western border of Range X; but it ought to be found on Triangle lake, and thence to Snowbank, near the western extremity; where evidences of its proximity have been observed. Eastward of Snowbank lake, its non-appearance may be attributed to the bed of gabbro which conceals the eastward prolongation of the White Iron granite. Farther east, we find the southern slope of the Saganaga granite encroached upon by the Animike slates; but north of Gunflint and North lakes, the fringe of crystalline schists appears, resting against the vertical beds of gneiss. This region is within the Canadian Dominion, and no attempt has been made to trace it farther.

The crystalline schists along the southern border of the Basswood granite, consist chiefly of muscovite and biotite schist; but with occasional hornblende schist and rarely a dioryte schist. Generally, these schists are not well characterized, being fine-grained, and in many places transitional in constitution. On the south side of Burntside occurs a good scythe-stone—a fine, homogenous muscovite-schist—but a mile or two further east, a massive hornblende schist usurps its place. In the belt as observed north of Gunflint and North lakes, biotite and hornblende both occur, sometimes in mixture and sometimes in alternation.

The mode of transition between the gneisses and crystalline schists is noteworthy. It is never abrupt. It is a structural gradation. In the neighborhood of the line of junction, beds of gneiss and beds of schist occur in many alternations. On the gneissic side of the line, the schistic beds are at first several inches in thickness, and of frequent occurrence, or else thin, and correspondingly augmented in number. As we recede from the line, the schistic beds grow thinner and occur less frequently. On the schistic side of the separating line, occur some gneissic bands of various thickness, all conformable with the schists; and often large angular fragments of gneiss, little or not at all displaced from bedded conformity with the schist. These phenomena were so fully described and illustrated in the fifteenth report that I have given them a less conspicuous place in the present one. One striking instance however, is described, occurring north of Gunflint lake, in which I estimated about five hundred thin bands of hornblende schist intersecting the gneiss within a breadth of forty-five feet. I have also described in this region, a direct mineralogical transition from earthy and sub-crystalline schists to gneiss, without the intervention of proper crystalline schists. The earthy schist becomes at first porphyritic with feldspar, and then with feldspar and quartz. While the proportion of these minerals increases, the groundmass resolves itself into nascent mica and then into well-formed individuals of biotite or hornblende, or both together. The significance of these structural and mineralogical transitions will be referred to in another connection.

3. *Kewatin semi-crystalline schists.*—In his "Report on the Geology of the Lake of the Woods Region" for 1885,* Mr. Andrew C. Lawson has applied the term "Kewatin" to certain schists occurring in the vicinity of that lake and holding position immediately above the granitoid gneisses. The geological survey of Minnesota has for two years employed this term, slightly modified, to designate provisionally a series of earthy and semi-crystalline schists holding a position next above the crystalline schists. In our usage therefore, the term is less extensive in application than in the original proposal of Mr. Lawson. Without citing at present, the classes of strata embraced under this designation in Canada, I will proceed at once to a summary description of the strata to which we have applied it in Minnesota.

(1). Distribution. These rocks occupy the whole of the south and east shores of Vermilion lake as far as Mud Creek bay and somewhat beyond. Thence the southern boundary of the belt passes half a mile south of Burntside and half a mile north of Long lake, and thence through Newton lake nearly to the most southern bay of Basswood and Arm I of the same lake. It continues eastward so as to pass between Basswood and Carp lakes, and thence northeastward into Canada—the northern limit of the belt lying north of Sucker, Pseudomesser and Knife lakes, and far north of Ottertrack, Oak and Saganaga lakes. All these lakes lie wholly within the Kewatin belt, except Saganaga, which only encroaches upon it along the northwestern border.

The southern limit of the Kewatin belt has been traced from a point south of Eaglenest lakes, T. 62-15, to the northern extremity of White Iron lake, thence across the north part of Farm lake, to Triangle and

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* Geological and Natural History Survey of Canada, 1885, CC.

Snowbank lakes. Following the west shore of Snowbank it leaves the north shore within the granitic area, but bends southward to cut off the eastern extremity of the lake, and proceeds thence to the vicinity of Kekequabic, where for the distance of two miles, it is overlapped by the gabbro sheet. East of the middle point of this lake, the system is revealed again, if we may venture to regard the Ogishke conglomerate as a part of it. But the southern border is overlapped by greenstone. As far east as the north shore of Gabimichigama, the system is largely exposed, with its character well preserved. Eastward of this, for twelve miles, the writer has not observed the Kewatin rocks. But north of Gunflint they recur in unmistakable character and continue eastward near the north shore o North lake into the remoter regions of Canada.

It will be observed, from the foregoing description, that no connection has been actually traced between the Kewatin schists north of Gunflint lake and those as far west as Knife lake. Along the national boundary, the Knife lake schists have been traced to the crystalline area of Saganaga lake, and thence along the northwest and north sides of that lake. The southern limit of the Knife lake schists and the Ogishke conglomerate, on about the meridian of the west end of Saganaga, is lost to view. Does it turn northward so as to throw the whole breadth of this Kewatin belt to the north of the Saganaga granite; or is the Kewatin belt here split—one branch passing to the north and the other to the south of the Saganaga granite? In the former case, the Saganaga granite would be continuous with the White Iron granite. In this case, the Gunflint Kewatin would be a distinct belt, and its westward continuation would have to be sought along the southern border of the White Iron granite. But even if in position there, it might be concealed by overflows of gabbro and greenstone, or by the vast Animike system. The strike of the Animike beds north of Gunflint is so much north of east as to suggest the opinion that the belt is separated from the main or northern belt by the interposition of the White Iron-Saganaga granitoid range. At the same time, its lithological characters very closely resemble those of the Knife lake Kewatin; and since rocks which I strongly incline to believe Kewatin, are traced eastward from Ogishke-muncie, through Town-line and Frog-rock lakes well toward the southern side of the Saganaga granitoid area, it rather appears probable that the Gunflint Kewatin is really a southern bifurcation of the Knife lake Kewatin.

No exposure of the Kewatin series has been observed by myself far-

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ther east than North lake, in the meridian of Range II west. But I have information apparently reliable, of its occurrence in a limited exposure as far east as South Fowl lake, in sec. 1, T. 64, R 3E. In the opposite direction it is found, according to a private letter from Mr. H. V. Winchell, in sec. 11, T. 59, R. 14W. It strikes here N. 80° E. The position seems to be on the south of the White Iron granite range.

(2). General lithological characters of the Kewatin schists. Vertical bedding is almost everywhere, within the region examined, distinct and unambiguous. In certain places, however, the bedding is obscure, or even completely obliterated. Such obscuration may often be traced in the action of erupted masses; but more often the hardened and metamorphosed condition of the strata is not ascribable to any visible cause. Passages from the more earthy to the more hardened condition take place along the direction of the strike, as also in a direction at right angles with it. The strike of these vertical schists is in general east-northeast in the region west of Saganaga lake, and somewhat more easterly in the region east of it. The directness of the strike is as remarkable as its persistence. The flexures of the strata are but moderate. It is only on the south of Ogishke-muncie, and about Fox and Agamok lakes that evidences of considerable disturbance are manifest Some of these features were described and figured in the report for 1886, pp. 168, 169, 375-378. On the north of Saganaga lake the strike still holds steadily east-northeast, and on the north of Gunflint lake it is not very different.

The beds for the greater part are even and continuous, and the cleavage is coincident with the bedding. The planes of sedimentation may frequently be detected by means of the usual banding. The universal coincidence of these, when discoverable, with the planes of the cleavage system, affords good evidence that the cleavage planes everywhere point out the direction of the original sedimentation.

Often, however, the bedding becomes irregular, the rock being resolved into a mass of lenticular and cuneiform pieces a few inches in length. This condition may pass by rapid transition into that of regular bedding.

In lithological composition the Kewatin schists present notable diversification. The principal rock species are: (1) Graywacke, (2) Argillyte, (3) Sericitic schist, (4) Chlorite schist, (5) Porphyrellyte schist, and (6) Hæmatite. The *graywacke* generally occupies a position nearest to the crystalline schists. Often, however, the sericitic and argillitic rocks graduate into a graywackenitic formation.

The best characterized graywackes are obscurely bedded, dark gray and composed of fine grains of quartz and feldspar mostly but not exclusively monoclinic, all imbedded in a sparse or copious groundmass of a silico-argillaceous character Disseminated through the rock are generally some black specks of an anthracitic character. Peroxide of iron also, is often present. From the condition thus described the variations are very marked. Often through an excess of quartz and a high silicification of the groundmass, the rock becomes impure-flinty, and under the influence exerted by heat, has acquired a ringing hardness, accompanied by two or three sets of jointage planes, which divide the mass into cuneiform portions. It thus seems to answer the description of *hornfels*. This condition is approximated very frequently. But, far from being persistent, we often see it pass rapidly into a well-bedded terrane. In another direction, the felsitic constituent exists in increased quantity, and the dark aspect of the other ingredients gives the rock a diabasic look, especially when, as is mostly the case, all bedded structure is completely disguised. At times it is almost impossible to decide macroscopically whether the rock is a real diabase, an anamesitic doleryte, or only an altered and aberrant graywacke. (Rep. XV, p 27.) As an instance of this may be mentioned the rock about the shores of Flask lake, in T. 64-9 W. Another is near the northern entrance to Garden lake (XV Rep., pp. 125-6, 68.) It is seen equally well developed on the north shore of Frog Rock lake and the southern part of Crab lake.

Another member of the Kewatin series is *argillyte*. In position it generally lies next the principal mass of graywacke. Argillytes well characterized exist in great abundance. Such may be seen from Vermilion lake to Knife lake. Newfound lake and Moose lake in T. 64-9 W., lie in the midst of an area of such argillytes. The slate is bluish or buffish, highly argillaceous, and cleaves smoothly and with great facility. Such slate exists less exclusively in the basins of Long, Fall, Ensign and Knife lakes. Other argillytes equally slaty and smooth-cleaving, but of a dark almost black color, are widely distributed and abundant. Of rare occurrence in the vicinity of Vermilion lake, they are quite increased in volume along some parts of Fall lake, and become predominant around the shores of the western part of Knife lake. Dark argillytes are also associated with the conglomerate of Ogishke-muncie, but these require separate mention. Many of the argillytes of Knife lake acquire a considerable percentage of silica, and become siliceous argillytes, retaining generally their free cleavability and characteristic color, which is mostly dark. The silicification of the argillytes has frequently gone so far that the rock is a strict *siliceous schist*, retaining generally, a dusky color, but sometimes acquiring a marked translucency. Generally, strata or laminæ of siliceous schist, flint, or red jasper alternate with laminæ or beds of dark siliceous or characteristic, argillyte. With these, sometimes, are laminæ of hæmatitic siliceous schist. In a large detached mass of this kind, found at the western extremity of Knife lake, the various laminæ were strikingly contorted. This màss was supposed to be not far removed from place; but no such character has been seen by the writer actually in strata of the Kewatin series so far west as Knife lake. But jaspery hæmatite has been observed between Nameless and Sand lakes, in T. 62-14. On the contrary, similar characters have been observed in the Animike schists north of the west end of Gunflint lake, and less contorted at other points along the north shore.

Besides the transitions above mentioned, the argillytes of Knife lake exhibit many transitions to *sericitic schist*. This may be observed taking place in the direction of the strike and also across it. Transitions to graywacke have been mentioned. The impression made upon the observer by these passages is a conviction that all these species of rock have been originally the same; and out of the same material, varying conditions, primary and secondary, have produced the diversified states of rock above described.

Another species of rock belonging to the Kewatin series is *sericitic schist*. This is generally of a light brown color and a silky or soapy feel. It is always distinctly and thinly laminated. By access of argillaceous matter, it often passes into a brown argillyte. When in a state of characteristic purity, it sometimes effloresces under exposure to the weather, giving rise to a powder, white like flour or tinged with iron peroxide. This schist is most abundant in the western part of the region studied, where it is associated with beds of hæmatite Eastward, it becomes a brown, smooth sericitic argillyte, but has only a local distribution. It occurs on the north side of Ensign lake, at one or two points in the northwest part of Frog Rock lake, and at several points on Town Line lake. Outcrops are also seen on the south side of Ogishke-muncie lake. A frequent characteristic of the sericitic argillyte is the occurrence of disseminated grains of free quartz. This character is quite striking at one point on the north of Ensign lake, on the south shore of the north part of Ogishke-muncie lake, and at two points on Frog Rock lake and several on Town Line

A fourth species of schist is *chloritic*. In full development it possesses a dark earthy green or bluish color, moderate hardness, and generally an imperfect and irregular bedding. The general trend of the structure is always conformable with that of the adjacent schists. An instance of the highest development of this schist may be seen at Kawasachong falls, in the stream flowing from Garden into Fall lake. As the nature of this rock is not yet settled by common consent, it is frequently referred to in this report as the "Kawasachong rock." A full account of its occurrence at this place may be found in the Fifteenth Report, pp. 319-322. The fully developed condition of the rock may also be seen at many other points—notably on the north side of Frog Rock lake, where I made a detailed study of it (page 306), and at the northern extremity of Pseudo-messer lake, in Canadian territory. It is reported largely distributed on the south of Long lake about the new iron mines.

Chlorite schist presents countless cases of gradation into sericitic schists and argillyte; insomuch that in my detailed descriptions frequent mention is made of "chloritic-sericitic schists" and "chloritic argillyte." The chloritic constituent also very frequently invades the graywackes. The question of the eruptive origin of any part of the chlorite schist will be considered hereafter.

A fifth species of schist occurring in the Kewatin series is *porphyrellyte*—a name of purely provisional import, and used here, while the rock awaits due investigation, simply to avoid the misapplication of any well-known term. This species of schist has been found existing in immense volume and over a wide extent of territory, especially between Sucker and Gunflint lakes. In tracing out the schists recognized as sericitic and argillitic, it was noticed that they sometimes acquire gradually a constituent which imparts a somewhat waxy lustre and waxy transparancy on thin edges. In the earlier observations about Vermilion lake, the siliceous constituent was sufficient to give considerable hardness to the rock, and such schists were set down as "felsitic." My earlier notes in 1886 contain occasional mention of "felsitic-sericitic schist" "felsitic argillyte" and even of "felsyte schist"—all the determinations, it will be remembered, simply macroscopic, and made in the field. In proceeding eastward similar rocks were occasionally noted; but in entering Sucker lake from the west, it was first noticed that the so-called "felsyte schist" was deficient in hardness, and I felt inclined to regard it as an "argillaceous felsyte schist." Uncertain of its real nature, I continued to note its occurrence in increasing abundance, as far as lake Kekequabic. Here, on

Stacy island, I found distinct and numerous feldspar crystals imbedded in it. Having a groundmass apparently feldspathic to a partial extent, this formation might have been set down as porphyry. But it was obviously of sedimentary origin, and was interbedded with slates. Also in the immediate vicinity, the forms of pebbles were traceable in the rock. Exactly similar observations were subsequently made on both sides of the narrows between Zeta and Dike lakes, T. 65-6W. (Fifteenth Rep., p. 158), but most satisfactorily on the north side. As the rock clearly was not an erupted and true porphyry, I designated it *porphyrel*. This pseudo-porphyry was subsequently met many times. Finally, along the two terminal bifurcations of the Fourth Arm of Knife lake, I was specially impressed by two groups of observations. *First*, the groundmass of the porphyrel was entirely too soft to admit the hypothesis of a felsitic nature; and *secondly*, the feldspar crystals appeared and disappeared at frequent intervals, while at some intermediate points they were very few in number, and sometimes appeared to be just emerging into existence from the general groundmass. (See rocks 549 and 954–5.) In all these cases the formation preserved a rude and irregular stratification. On the north bifurcation of the Fourth Arm of Knife lake, *porphyrellyte* is the prevailing rock; and it rises in many massive bluffs on both sides. In a small bay near the eastern extremity, it becomes a porphyrel, and here, as at Kekequabic (west end of Stacy island and rock 360) and Zeta lakes, the outlines of pebbles may be traced. At the "Promontory of Knife lake," which separates the Fourth Arm from the body of the lake, an argillaceous porphyrellyte is capped by a thick sheet of gabbro (p. 209). A more characteristic porphyrellyte is capped by gabbro on the eastern shore of the southward projecting bay near the eastern end of Knife lake (p. 206). On the north side of Gunflint lake, the vertical schists range from porphyrellyte to argillaceous porphyrellyte and porphyrel. The latter acquires also, in some parts of this region, abundant grains of quartz.

In most of the localities where porphyrellyte occurs it is found alternating with argillyte — sometimes of a slate color and sometimes dark or almost black. The local relations of these different varieties of schist are well illustrated on the south side of the north bifurcatio of the Fourth Arm of Knife lake. The passage is both along the strik and across it — in either case reflecting light on the genetic relation of the two. In the same region, but chiefly on the north shore, th porphyrellyte may be seen passing into a hardened flinty argillyte, a also into a condition having a diabasic aspect — hard, and almos without bedding. A puzzling condition occurs on the north side of Frog Rock lake, where toward the east, felsitic-looking bosses alternate with diabase-looking bosses, chloritic bosses and real diabase. Never, however, as far as I have traced the Kewatin schists, does the translucent, waxy constituent permanently disappear. This seems to be the fundamental material out of which nature has produced not only porphyrellyte and porphyrel, but also some sericitoid and argillaceous schists, and even some hard diabase-looking rock-masses. These indications led me to designate as "Kewatin stuff" the fundamental mineral which has revealed itself under so many aspects.

The diversification of porphyrellyte may be traced in another direction. Already when making observations in the vicinity of Vermilion and Eagle Nest lakes, I discovered small serpentinous lumps (XV Rep. p. 32) and thin films in that modification of Kewatin rocks reported as "porodyte"— after Wadsworth. I recorded the opinion that the rocks of that vicinity were pervaded generally "by a magnesian element." Next, I subsequently observed in the southern bifurcation of the Fourth Arm of Knife lake, that porphyrellyte passes by insensible gradations into porodyte; and I learned that Knife lake porodyte is only another of the modifications of "Kewatin stuff." Again, the obscurely conglomeritic character of some examples of porphyrel has been noted in several places. Now let the feldspar crystals disappear from conglomeritic porphyrel, and it approaches closely to some states of the so-called "Stuntz conglomerate"—of which I shall have a word further to say. It thus appears that the basal substance of porphyrellyte reveals its existence under a very interesting variety of modifications.

The nature of that basal substance remains to be determined. But meantime, while awaiting opportunity to make appropriate investigation, I have considered the possibility that Kewatin stuff is essentially *parophite*, a form of pinite, a hydrous, aluminous alkaline silicate. Such composition would account for porphyritization with either feldspar or quartz, or both conjointly; and as magnesia is a constant alkaline constituent (together with potash) we have means of explaining the occurrence of serpentinous lumps in the porodyte of Vermilion lake — if indeed, they be not parophite or agalmatolite instead.* The formation here considered seems to bear no relation to the "Serpentine Group" of Rominger.†

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* Parophite is a name proposed by Dr. T. S. Hunt, from the resemblance of the rock to ophite or serpentine. See Report, *Canadian Geological Survey*, 1851-2, pp. 95-99; *Geology of Canada*, 1853, pp. 481-6

† Rominger, *Geological Survey of Michigan*, vol. iv, pp. 131-143.

Should it be supposed that the porphyrel above referred to is probably a true erupted porphyry the following may serve as adequate reasons for thinking otherwise:

(a) The vertical structure which exists seems to include the vestiges of an original sedimentary stratification. This structure is the result of stratification and schistosity combined. Sometimes the slatiness is conspicuous (Rock 955).

(b) The porphyrel, in numerous cases, reveals the original presence of pebbles, the outlines of which are now obscured, and *the nature of which has probably been changed.*

(c) The porphyrel passes insensibly into porphyrellyte which (besides retaining its traces of stratification) exists in such volume that it would strain credulity to believe it eruptive.

(d) The groundmass of the Ogishke conglomerate — beyond all question fragmental in origin — sometimes, as has been stated in the former part of this report, develops feldspar crystals, and becomes in form and substance, an argillaceous porphyrel.

(e) Porphyrel and porphyrellyte are found interstratified with dark siliceous argillytes. See page 324.

(3) The Ogishke dolomyte. Having stated concisely the characters of the predominating rocks of the Kewatin series, I make brief mention next, of lithological features more or less local and exceptional. *Dolomyte* has been observed at only one locality. That is near the shore of the northeastern part of Ogishke-muncie lake. It is vertically bedded, mostly impure, stained with iron oxide, crumbling, pervaded by sericitic matter and passing laterally into conformable beds of sericitic schist. The strike is parallel with the axis of this part of the lake. It was traced only a few rods. For further particulars, see pp. 95, 316.

(4) The hæmatite lodes of the Kewatin. These have not fallen within the scope of observations made in 1887. Such facts as were observed in 1886 may be found recorded in the fifteenth annual report.

(5) The conglomerates of the Kewatin. The *Ogishke conglomerate* is limited to the vicinity of Ogishke-muncie lake. On the west it is seen first at Stacy island in Kekequabic lake; but occurs also along the north shore of the eastern part of the lake. Its northern boundary passes a little north of Alpha, Beta and Gamma lakes, sec. 29, T. 65-6, and thence eastward to the portage between Zeta and Dike lakes, thence to the portage between Zeta and Ogishke-muncie lakes, thence northeastward so as to cut off half a mile of the eastern end of Crab

lake; thence east to the northern side of Town Line lake; then southeast to the centre of sec. 18, T. 65–5, on the northwest shore Frog Rock lake. From here the boundary is lost. The conglomera does not appear on the west or south shore of Frog Rock lake. Fro the point of occurrence last mentioned the boundary must pass south-west. Section 24, T. 65–6, is within the conglomerate area. Th southern border is found near the outlet of Agamok lake, in sec. 36, T. 65–6, and again near the centre of sec. 35, T. 65–6, on the mountain slope, a mile south of Ogishke-muncie. But from here the boundary bends suddenly northward to the N. E. ¼, sec. 26, T. 65–6, and thence southeast to S. E. ¼, sec. 27, T. 65-6. Thence the southern border bends southeasterly, passing to the east of Twin peaks in S. E. ¼, sec. 34, T. 65–6. The continuation westward is now unknown for the space of two miles, the southern boundary being struck again on the southeast of lake Kekequabic in sections 31 and 32, T. 65–6. The area thus circumscribed has an extreme length of eight miles and an extreme breadth of two miles or a little more.

The Ogishke conglomerate is composed of beds standing vertical, with slight inclinations one way and the other. There seems to be a general strike in an east and west direction, and in places this strike is distinct for a quarter of a mile or more, especially near the borders of the conglomeritic area. Within the area, the strikes are mostly obscure; but when distinct, they conform to the general trend. In many places however, the strike seems to vary much from the normal direction. This is seen along the immediate shore of the lake, and on the mountain slope south of it, as also in the vicinity of Fox and Agamok lakes. In the last named region, a centre of disturbance seems to be revealed (Fifteenth Report, pp. 168-9). It must be noted however, that the magnetic needle, around the shore of Ogishke-muncie, deviates with much irregularity.

Considering more carefully the lithological character of the beds, we find the groundmass in which the pebbles are imbedded, to be essentially a dark slaty argillyte, varying from a typical argillyte through all the conditions already noted in the argillytes of the Kewatin series—cleavable, badly cleavable, siliceous, feldspathic, hard-baked and "diabasic." The pebbles are not uniformly distributed through the formation. They lie in courses coincident with the strike, and their longer axes generally lie in the same direction Some of the slaty beds are well filled with pebbles large and small; others contain but few, and these mostly small. Again, we find many beds entirely destitute of pebbles; and this condition exists in places across a breadth of ten or twelve rods, to be succeeded again by conglomerate. The transition is apt to be abrupt. A bed well filled with pebbles is likely to be succeeded by beds without pebbles, and possessing all the characters of an ordinary argillyte (See Fifteenth Rep. p. 163). These variations are well seen around the shores at the west end of Ogishke-muncie.

The limits of the conglomerate area are not abrupt They are indicated by the gradual diminution in the proportion of pebbles, and in their size. In the direction of the longer axis of the area, this is well seen at Stacy island in lake Kekequabic, while the vanishing point in the opposite direction is seen in the northwestern part of Frog Rock lake. In this direction the diminution in the size of the pebbles is a more signal feature than in the transverse direction. On the mountain south of Ogishke-muncie the country rock undergoes a change into a formation resembling greenstone; and in this large bowlders are sparsely disseminated. A similar observation is made on the north of Ogishke-muncie. In the greenstone condition, the outlines of the pebbles become much obscured, while at the east and west extremities of the conglomerate area, the diminished pebbles remain well isolated.

Another course of variation is observed in the vicinity of Ogishke-muncie lake. The same transitions in the state of metamorphism of the mass of the formation take place as have been noted in reference to the graywackes and argillytes farther west. In limited districts the smooth rounded bosses of the conglomerate present a striking resemblance to diabasic outbursts. But these in most cases. are distinctly siliceous; in others, the groundmass contains numerous individuals of feldspar. Many times the pebbles are nearly or quite concealed by the change which has affected the formation. Sometimes the forms of pebbles are completely undiscoverable above the water-line, while sufficiently distinct beneath it. These conditions are best exposed on the western and southern shores of Ogishke-muncie. On the eastern shore, north of the northern narrows, and at a distance inland, the diabasic aspect of the formation and the obscurity of the pebbles are very noticeable features.

Another feature of the highly metamorphic conditions of the formation is the *metamorphism of the pebbles*, as well as the groundmass. By this means the mineral nature of the pebbles is approximated to that of the groundmass, and thus the obscurity of their outlines is caused. The pebble-bearing "green rock" on the mountain south of Ogishke-muncie, seems to be one of the results of metamorphic change

Fifteenth Rep., p 165). But I do not mean to assert the absence of erupted greenstones in other parts of the same range. A similar change has been suffered in the ridge a mile north of Ogishke muncie.

As to the pebbles themselves, it may be stated that their most conspicuous features are their strictly smoothed spheroidal forms, the diversity of their mineral characters and their prevailing arrangement in courses. Evidently, these rock-fragments have been long rolled on some ancient beach. Their sizes range from a quarter of an inch to ten inches; and the groundmass is locally composed largely of the same materials in a finer state. This is seen on the main land north of Camper's island. Without attempting a complete enumeration of kinds, the following may be named: (1). Syenite, resembling Saganaga syenite but with little hornblende; (2). Greenstone; (3). Porphyry; (4). Red jasper; (5). Flint; (6). Quartz, opaque, white; (7) Petrosilex; (8). Ordinary syenite with black hornblende; (9). Dioryte, coarse, with dark green hornblende; (10). Dioryte, fine, with dark green hornblende, (11). Porphyroid, weathering light and cellular; (12). Siliceous schist; (13). Carbonaceous, siliceous argillyte—sparingly. The foregoing list was made out on Camper's island near the narrows in Ogishke-muncie lake. This is about the centre of the most characteristic portion of the formation. In all directions from there the diversification of the pebbles diminishes. On Stacy island however, in Kekequabic lake, the conglomerate is slightly brecciated, and the fragments consist of fine diabase, dark siliceous schist, red jasper and black flint, all imbedded in a matrix of dark color, looking somewhat like the overlying dark slate.

The relative age of the Ogishke conglomerate is a difficult question which cannot be regarded as settled. The *prima facie* evidence would make it a part of the Kewatin system, conformable in structure and consecutive in history. The fundamental rock-stratum holding the pebbles is essentially an argillyte presenting the same characters and subject to the same variations as the argillyte of Knife and Pseudomesser lakes and the region further west. On the northern boundary the formation visibly passes from Ogishke-muncie by diminution and final loss of pebbles, into the argillyte of Zeta and Epsilon lakes From Kekequabic, it graduates similarly into the argillytes of Pickle, Spoon, Plum and Knife lakes. On the west it is traced by absolute continuity into the argillyte of the western Arm of Knife lake, and thence through Sucker, Ensign, Newfound and Moose lakes. The argillytes and associated schists of the series as found at Ensign and contiguous lakes, are admittedly in continuity with the argillytes and associated schists found at Long, Sand, Eagle Nest and Vermilion lakes. Moreover, we find in the area of the conglomerate itself, local developments of sericitic schists, such as farther west are so largely associated with the argillytes. These are found on the shore of Ogishke-muncie lake south of Camper's island, and farther north on the south shore, associated with the dolomyte above described. Such schists are elsewhere found within the conglomerate area, on Town Line and Frog Rock lakes. To make the identification more complete, the sericitic schists of Frog Rock and Town Line lakes are filled with quartz grains, precisely as the recognized Kewatin sericitic schists are charged with them on the north shore of Ensign lake. Finally, as the porphyrellyte of Zeta, Dike, Knife and Gunflint lakes becomes locally charged with feldspar crystals, so the groundmass of the conglomerate becomes similarly charged at many points on Zeta, (rocks 916–17,) Kekequabic and Ogishke-muncie lakes. Lithologically and stratigraphically, therefore, the identification seems to be complete.

The structural continuity can be traced still farther east and northeast. The vertical porphyrellyte schists of the eastern part of Knife lake alternate with dark argillytes traced from the western part of the lake, and are to a large extent, in continuity with some members of them. At the northeastern extremity of Knife lake, the argillaceous porphyrellytes disappear from observation in the direction of the northwest shore of lake Saganaga. Along that shore they are re-discovered. In the regions last mentioned, the argillaceous porphyrellytes exhibit characters exceedingly similar to the schists seen north of Gunflint lake and traced still farther east. We seem to discover therefore, an unbroken continuity between the western schists and the eastern. The Ogishke conglomerate lies between the two; and in making their connection they seem to pass through the area of the Ogishke conglomerate On structural as well as lithological grounds, the conglomerate seems to belong to the Kewatin series.

As to its position in the Kewatin series we have some facts to aid the formation of a judgment. The conglomerate is succeeded northward from Ogishke-muncie and Kekequabic lakes, by vertical schists in the following order: 1st. Dark argillytes (Pickle, Plum and Knife lakes); 2d. Graywackes (IVth Arm Knife lake), porphyrellytes (IVth Arm Knife lake) and porodytes and Stuntz conglomerate (IVth Arm, southern bifurcation); 3d. Porphyrellytes (IVth Arm, northern bifurcation, and thence across the main body of the lake into Canada). There is some appearance of a reversal of the order of succession in the recurrence of a broad belt of porphyrellytes; but neglecting that question, the occurrence of porodyte and Stuntz conglomerate on the north indicates a high stratigraphic position for the conglomerate; since porodyte, in the vicinity of Vermilion lake, holds place near the base of the Kewatin series. Moreover, porphyrellyte, passing downward into porphyrel, is found at Gunflint lake, to stand in close relations with the crystalline schists.

Again, it has been shown (Fifteenth Rep., p. 165) that on the southern border of the conglomerate area, the prevailing dip of the beds is northward at an angle of 50°; while it is shown in this report (p. 322) that at the southern point of Epsilon lake—just north of the limits of the conglomerate, the argillyte has a southward dip of 75°. These indications, so far as they go, place the Ogishke conglomerate in a synclinal basin, at the top of the Kewatin series.

It will be remembered that reasons exist for concluding that the Kewatin series bifurcates in this vicinity, one branch passing to the north and the other to the south of the Saganaga granite. Thus a triangular space exists between the diverging branches on two sides and the (apparently) obtuse termination of the granitic mass on the west. It is not clear how these relations would help to an understanding of the geological history of the conglomerate. If, however, the superposition of the conglomerate is correctly induced. there must have existed at one time, a sea or bay of limited extent, in which coarse pebbles from rapidly crumbling shores were copiously accumulated. As probably the uplift of the granitic mass has taken place since that time, and the schists thus thrown into their disturbed positions, the configurations now apparent would convey no conception of the relations of land and water during the formation of the conglomerate.

A different conclusion in reference to the age of the Ogishke conglomerate may possibly be entertained. That view identifies it with the Animike series; and I postpone the consideration of it until that series shall have been sketched.

It is not to be supposed that the small area of Ogishke conglomerate above described is the only conglomeritic product of that epoch. It is worthy of inquiry whether the wide-spread pebbles of the Saganaga granite, and which culminate in abundance on Wonder island in Saganaga lake, and on the west of Seagull lake, may not have been derived from the same sources of supply. It is true the pebbles in the ranite are much less diversified in character, and approach generally he nature of greenstones. But it has been shown that the pebbles of he conglomerate approach a similar condition in situations where thermal agencies have acted most efficiently. As in the gneisses, such agencies have been far more transforming than in any terrane retaining some portion of its original sedimentary arrangements, the difference in the nature of the pebbles in the two formations is not sufficient ground for denying their community of origin. It is also true that in regions further south, bowlders closely resembling the indurated portions of the Ogishke conglomerate are of frequent occurrence. The relation between this conglomerate and those described by Sir William Logan, and ascribed to the Huronian, cannot be here considered. I will only express my present conviction that the Ogishke conglomerate may be identified with that occurring at the mouth of the Doré river, near Gros Cap, lake Superior;* but seems a different one from the "slate conglomerate" of the valley of the Thessalon river north of lake Huron.†

The *Stuntz conglomerate*, as above indicated, is not to be confounded with the Ogishke conglomerate. It holds a lower stratigraphical position, is generally more obscure in its characters, and has a matrix possessing less a slaty than a porodytic character. Its lateral development is also inconsiderable. Its name is derived from Stuntz bay of Vermilion lake, in the vicinity of which the formation is most clearly exposed; but I have also identified it on the south shore of Knife lake. At some points about Vermilion lake it appears as an ordinary conglomerate, with pebbles quite foreign to the matrix in which they are imbedded; but in other situations, the matrix assumes a diabasic appearance, and the pebbles are but imperfectly differentiated from it. This feature is analogous to conditions found in the Ogishke conglomerate. It is the latter condition only which occurs on Knife lake.

As only a small development of this formation has fallen within the field of my own observations, I have no occasion to make further mention of it.

(6) Relation of the crystalline and Kewatin schists. The Kewatin schists above described pass downward somewhat abruptly into the crystalline schists of the "Vermilion group." In stratigraphic relations the two series are everywhere perfectly conformable. The possibility is recognized, however, of an original unconformity which has been destroyed by violent lateral pressure after upheaval. Yet, I think such original unconformity improbable in this case. Nevertheless, a geologic break must be recognized in the interval between them. The conditions under which the upper and more earthy have

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* *Geology of Canada*, 1863, pp. 52 and 53.

† In this I differ for the time being from my brother (*American Geologist*, 1. p 14). But final studies will probably bring us into harmony.

resulted are thoroughly different from those under which an entire group of rocks underlying has been crystallized and foliated. There is no historic continuity between them. They belong to different ages.

Mineralogically, the relations of the two series possess much interest. In spite of the inferential break between them, the metamorphic agencies which have given exclusive character to the lower seem to have encroached slightly upon the older beds of the higher. In repeated instances I have noted a gradual passage from graywacke to fine mica- or hornblende schist. But a more striking observation is the passage of porphyrellyte to gneiss, as already described. The process shows how, in some cases, the interposition of crystalline schists between the Kewatin schists and the gneiss has been prevented. It also serves to establish an affiliation between schists admittedly sedimentary in origin and schists sometimes relegated to the category of eruptive rocks.

(7) Are any of the chloritic or sericitic schists of the Kewatin eruptive? I have stated that the fully developed chlorite schist, known to our Survey as Kawasachong rock, presents some characters which suggest an eruptive origin. It has a rather remote resemblance to some old decayed diabases in which a rudely bedded structure has been imparted by pressure and cleavage. In some cases it seems to present the condition of an obscure dike, conformable with the bedding of the country rock; but generally, it would be regarded rather as a vast overflow. The deficiency of siliceous matter favors the same view.

The following facts of observation may be mentioned as opposed to this view. The "Kawasachong rock" appears to be absolutely continuous with schists which are simply chloritic and admittedly of sedimentary character. These are continuous with schists described as "chloritic-sericitic" or "chloritic-argillitic." It has the same vertical bedding, though obscured, and this conforms with that of the adjacent schists. These chloritic rocks then, are all one mass, and of one origin. Again, if the Kawasachong rock were an eruption, it should disclose somewhere, unmistakable lines of limitation. Instead of this it always fades into the contiguous schist, and loses its proper characters, without the possibility of fixing its bounds These limitations are wanting equally in a vertical and a horizontal direction. And lastly, in addition to being incorporated as a constituent in a system of schists, its volume is too vast, and too widely distributed to permit the probability of its eruptive character.

Similar statements may be made *pro* and *con*, respecting the origin of the sericitic schists, or any portion of them. The discovery of bedding as a result of pressure and motion—even bedding in many eruptive masses, should not lead to the following of a fashion which ignores the obvious and primary significance of the bedded arrangement in rocks.

4. *The Animike series.*—The term Animike is introduced into Minnesota geology, from its use by Dr. T. S. Hunt as the designation of a remarkable series of schists occurring on the west shore of Thunder bay of lake Superior.[*] Their identity with the typical Huronian rocks found north of lake Huron, was detected by professor R. D. Irving, and is fully established by personal studies made by my brother and myself in 1887.[†]

(1) Distribution. The Animike rocks stretch from Thunder bay southwestward as far as Duluth, and still beyond to the Mississippi river. The lake-shore belt however, from Grand Portage, for an average width of about twenty miles, is occupied by rocks of the Kewenian or copper bearing series—including portions of the lake Superior sand-stone. I have studied them along the international boundary from Grand Portage to Gunflint lake, from which they continue westward for at least four or five miles, and possibly to the vicinity of Ogishke-muncie lake. There is reason to suppose that some of the black slates as far west and north as Knife lake belong to this series.

At Gunflint lake and eastward, the formation assumes a striking character, and contributes to a peculiar physiognomy. The surface presents a series of ridges or ranges approximately parallel, but much broken in their continuity east and west. The ridges have the appearance of a succession of monoclinals dipping southward. The basal portions of the ridges consist of strata of the Animike series, dipping gently southward, and presenting on the south an easy declivity, while the north is precipitous and exposes the edges of the strata. The summits are crowned with gabbro. The numerous lakes occupy the depressions between, so that the southern shore of each lake presents a frowning precipice while the northern shore is low, but often gabbro-covered, with the surface gently rising northward. It is nat-

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[*] Hunt, *Trans. Amer. Inst. of Mining Engineers*, vol. i, p. 389. Full descriptions of the formation may be found in Logan's *Geology of Canada*, 1863, pp. 66-70; and more extended in Irving's *Copper-bearing Rocks of Lake Superior*, in monographs of the United States Geological Survey, vol. v, pp. 367-386. Also, Third Annual Report U. S. Geol. Surv., pp. 157-163. Consult also, Bell, in Geological Survey of Canada. Report for 1866-69, pp. 318-19, and Report 1872-73, pp. 92-3.

[†] N. H. Winchell "*On the Original Huronian*," American Geologist, I, pp. 11-14, Jan. 1888

Prof. Irving went further, and identified with the Huronian, the iron-bearing rocks of Marquette, Menominee, Gogebic and Vermilion lake.

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) but rests on the obscure vertical edges of a gray-
On an island in the eastern part of the lake,
ts overflowed by gabbro are seen to have a strati-
ep., p. 171). It is probably the same rock which
d in Illusion lake (XV Rep., p. 145). On the
lake (this Report, p. 305), "muscovado" occurs
glassy feldspar and has been reported a quartzyte.
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a feeble development, and here appears to lie be-
bed of the Animike. Finally, at the iron loca-
of Gunflint lake, a couple of beds aggregating

siliceous—especially the jaspery, bands, are found on the north shore, though most of the pebbles are accumulated on the east and southeast shores. The brecciated and contorted conditions of the formation involve the portion with siliceous bands.

(3) The magnetitic beds. Embraced in the Animike slates are beds charged with magnetite, hæmatite and siderite. These also hold position in the higher parts of the cliffs along the south shores of the lakes; and frequently the richest impregnation is in close proximity to the overlying gabbro. On the north and west sides of Gunflint lake, magnetitic beds lie near the water-level, and for some miles west of the lake they are quite extensively exposed or accessible. The principal beds are two to four feet in thickness. In the richest condition the magnetite attains a high percentage of the whole mass, and is black, coarse-granular, and metallic in lustre. But from this condition the percentage of iron graduates down to a quantity barely perceptible. These fluctuations in richness exist both in a vertical and a horizontal sense. The magnetitic beds on the north and west shores are generally uncovered; but on the north shore of the Animike bay, near the west end, a heavy gabbro deposit is found above the Animike at an elevation of about twenty to thirty feet. The same relation to the gabbro deposit obtains along the south shore of this and other lakes at levels ten times as high. The indication from these facts is that the iron holds place in the upper part of the formation, but apparently, not at the top in all cases. The difference of topographic level on opposite sides, also indicates an uplift along the south side, and a fault along the axis of the lake, as before suggested. The stratigraphic position of the magnetitic beds is also indicated by their position near the surface of the formation at the test-pits two miles west of the head of Animike bay. The subject is considered with full details, on pp. 267,268, illustrated by figures 48 and 49. The magnetite has by some writers been located in the lower part of the Animike; and on the theory of the formation of the lake-basin by erosion, the position of the magnetitic beds along the north shores, would give color to such an opiniou.

The siliceous and magnetitic beds being both located in the upper part of the formation—at least in the same part of it—the two characterizing constituents are often found in the same stratum. But besides the frequent silicification of the formation in proximity to the overlying gabbro, it is quite frequently found changed in such a manner as to simulate the aspect of the gabbro. After studying, inch by inch, the petrographic condition of the slate, from a point five feet below the gabbro up to actual contact, I find sometimes a progressive assimilation to the gabbro, so that the actual plane of contact would be unidentifiable if a similar graduation existed at all neighboring points in the vicinity. The fact is singular that in some cases the black slate preserves its characters little changed quite up to the base of the gabbro. I think it may be stated that the change is greatest where the magnetite is most abundant. In one place where examinations were made, the magnetitic bed was found uncovered at the lake shore, and the gabbro was discovered in the vicinity, at an elevation 30 feet higher, resting on dark slates. These slates were much less altered than in other places of contact with the gabbro. They were also less magnetitic. The indication is that above the main bed of magnetite is a series of slates magnetitic or not. When not so, they have suffered less change than when otherwise.

Some of the ferriferous beds appear to be simply hæmatitic I have surmised that this condition has sometimes resulted (as it certainly has in some gabbros) from a change of the magnetite. Equally probable is the production of hæmatitic beds from an original sideritic condition. Such condition is conjectured as present in many cases, but opportunity has not as yet been afforded for settling the question.

A terrane of an obscure character remains to be mentioned. This is known to the Minnesota Survey as "muscovado," and sometimes also to the writer, as "gabbroloid." It is composed, as far as field studies enable me to judge, of a fine granular mass of feldspar and quartz in an almost impalpable groundmass of the same materials mingled with aluminous matter. It often contains fine scales of biotite, grains of olivine and specks of carbonaceous or anthracitic matter. It has, therefore, some relation to graywacke. On the southern shore of lake Gabimichigama, it does not reveal any bedded structure (XV Rep., pp. 70–1,) but rests on the obscure vertical edges of a graywackenitic terrane. On an island in the eastern part of the lake, muscovado fragments overflowed by gabbro are seen to have a stratified structure (XV Rep., p. 171). It is probably the same rock which was seen on an island in Illusion lake (XV Rep., p. 145). On the north shore of Iron lake (this Report, p. 305), "muscovado" occurs which contains much glassy feldspar and has been reported a quartzyte. Its position here is beneath a mass of magnetitic gabbro, and its structure is obscurely bedded. It occurs also on the north shore of Animike bay, under a feeble development, and here appears to lie beneath the magnetitic bed of the Animike. Finally, at the iron location two miles west of Gunflint lake, a couple of beds aggregating eight feet in thickness, and approaching "muscovado" in character, are seen immediately beneath the magnetitic bed. It is not seen at the test-pit. because its position is lower than the lowest bed exposed in the pit, as shown in Figure 49.

It appears, therefore, that this terrane is a member of the Animike. If it is properly identified at Gabimichigama lake, the inference is, that the thin border of the Animike reaches as far north as that point; and that further exposures of Animike ought to be found by exploring further south—for instance, on the shores of Little Saganaga. It will be noticed, however, that the muscovado of Gabimichigama *retains its characteristic horizontal position, and that a vertically bedded terrane underlies it.*

There is indication that the very highest beds of the Animike are simple argillytes with little magnetite or none; and that the absence of the magnetite explains the comparatively unaltered condition of the slate where the gabbro rests upon it. These beds, however, do not appear to be over twenty or thirty feet thick.

Nothing can be stated with definiteness respecting the total thickness of the Animike series in Minnesota. The maximum thickness observed in one place is in the cliffs of Rove lake and of North and South Fowl lakes. Mount Reunion of Rove lake exposes a bluff of slates to the hight of about 100 feet above the lake. The lower 50 feet however, are concealed by a talus. At the outlet of South Fowl lake is a hill which I calculated to be 288 feet high. As about two-fifths of the altitude is gabbro, the thickness of the underlying Animike is about 175 feet, if it extends to the water-level.

Probably it extends much lower. The distance from this point in a straight line to Partridge falls is 6.7 miles. The direction of Pigeon river between the two points is about southeast, and the whole descent may be estimated at 100 feet. The dip of the Animike slates is about 8° toward S. 10° E. The distance between South Fowl lake and Partridge falls corresponds to a distance of 5½ miles across the strike of the schists; and this distance, with dip assumed, corresponds to a vertical thickness of 4,032 feet. If to this we add the hight of the schists at South Fowl lake, we should get 4,200 feet as the apparent thickness of the Animike between the two points assumed. This would not be the total thickness, since it is known to continue still farther in the direction of the dip.

From the lithologic details given, as well as from the slight inclination of the formation, it becomes very apparent that the Animike of Minnesota is the equivalent of the "slate conglomerate" of the typical

Huronian of Canada, as described in the earlier pages of this report. Another determination of even greater importance is afforded by the facts to which I now proceed to refer.

(4) Unconformities of the Animike. Professor Irving of the United States geological survey, had ranged under Huronian not only the Animike slates of Minnesota and other regions, but also the slates holding the vast hæmatite deposits of Vermilion lake and other districts in the lake Superior basin. But it has been my good fortune to make observations which demonstrate that the Animike and Kewatin rocks belong to different geological systems. A brief announcement of observations made in August, 1887, was published in October,[*] and some additional details in December last.[†] Fuller details are embodied in § 12 of this report. It is therefore only necessary in this place to summarize the facts to which I refer. With professor Irving it was a problem not satisfactorily resolved, to reconcile the horizontal position of the Animike slates of Gunflint lake and Thunder bay with the vertical position of the schists called in this report Kewatin, on the supposition which he made, that the horizontal and vertical slates are identical, and both Huronian. With this problem before my mind, I sought diligently for the continuous passage of the horizontal schists of the east into the vertical schists of the west. The vertical schists were lost, going eastward, on the southeast side of Seagull lake. The horizontal (Animike) schists were found seven miles further east, at the western extremity of Gunflint lake. I was preparing to undertake the arduous task of exploring the intervening region, when fortunately, I rediscovered the vertical schists on the north shore of Gunflint lake. The Animike beds had been seen on the east and on the west of this point. I therefore studied, foot by foot, the region separating these vertical schists from the Animike on the east, and traced the two, unchanged in attitude, to within seven feet of actual contact. They were there as contrasted in petrographic characters as in stratigraphic position. The one was *not* continuous with the other They were not only two different formations; they were *two systems*. The reader will turn to the earlier part of this report for the details of facts. The vertical schists were subsequently found in this vicinity under a great development,[‡] but reaching the shore of the lake only for a limited distance.

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[*] *Amer. Jour. Sci.*, III, vol. xxxiv p. 314.

[†] *Unconformities of the Animike in Minnesota*, American Geologist. pp. 14-21, Jan. 1888.

[‡] Later, I noticed that these schists had been mentioned by my brother as early as 1880, in the *Ninth Annual Report*, *Geology of Minnesota*, p. 82; and he then pronounced them "another and distinct formation from the slates at Grand Portage." They were apparently referred to again in the *Tenth Report*. 1881, p. 88.

In the last elaborate paper published by professor Irving, he gives a figure* quite similar to my figure 44, but he falls into an error in the interpretation of the facts. Regarding the flat-lying Animike as identical with the iron-bearing formation of Vermilion lake, he thinks the vertical schists shown in the figure to belong wholly to the crystalline series. They *are* the crystalline series at the right of the figure; but at the left they graduate, as at Vermilion lake, into the entirely conformable, hæmatitic, Kewatin series. Thus the Animike slates are truly unconformable with the hæmatitic schists. There is another difficulty in professor Irving's interpretation. On his view, the iron-bearing series is abruptly unconformable with the older crystalline schists. The fact is, that every observation made in Minnesota, bearing on the relations of the two, shows the Kewatin iron-bearing schists completely *conformable* with the crystalline schists. This objection can hardly be disposed of.

But the unconformity of the Animike with the Kewatin schists does not depend for proof on a single illustration. On the north side of Epsilon lake, T. 65-6, the two formations are found again in contact. The unconformity is disguised by a common system of vertical cleavage planes running through them; but by careful search I succeeded in finding the sedimentary ribboning of the Kewatin slates coincident with the cleavage, while the conspicuous ribboning of the Animike slates made a large angle with the cleavage. These facts are illustrated in figure 59 of this report.

After leaving the field I received information of another stratigraphic unconformity in the far east, in sec. 1, T. 64-3E. While this report is in press, I learn of still another, far to the southwest. Mr. H. V. Winchell writes, under date of Aug. 5, 1888: "Horizontal, black Animike quartzyte containing iron ore, lying (unconformably) on the vertically bedded Kewatin, which strikes N. 80° E. is found in sec. 11, T. 59-14W. The Animike is found nearly at the top of the Giant's range," This locality is about fifteen miles south of Tower.

The superposition of the (supposed *upper* beds of the) Animike slates on the flanks of the Saganaga gneiss has been described in this report, and illustrated in figures 48 and 49. It seems probable that many of the depressions in the old eroded surface of the Kewatin, in the region from Gunflint lake to Knife and Sucker lakes, were filled with the sediments of the Animike. Subsequently the whole region, and both systems of strata have been subjected to the common action which has imparted to both that wonderfully persistent and uniform vertical schistosity which is so striking a feature.

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* In the second part of a memoir published in the *Amer. Jour. Sci.*, III. vol. xxxiv, p. 261 fig. 9.

I have heretofore recorded my impression that certain black argillytes found in the vicinity of Negaunee, Michigan, as well as similar argillytes seen in the Gogebic range, are probably members of the Animike. It seems probable also, that the black fine-grained slates and interlaminated siliceous beds of Carp river, in the Upper Peninsula of Michigan, may sustain the same relations. A similar judgment may be passed on the slates of l'Anse and Huron bay—the lighter colored of l'Anse creek constituting an upper division. the banded slates alternating with compact siliceous beds partly light and partly dark constituting a middle division, and the roofing slates, a lower division. It is worthy of inquiry also whether the dark slates described by Houghton, in the interior, southeast from the Porcupine Mountains and the Montreal river, may not also be equivalents of the Animike. Some of the quartzytes and argillytes of the Menominee river, were referred by Houghton and Emmons, as the latter states, to the Taconic; but it is not unlikely that they represent the Animike.[*]

(5) Must the Ogishke conglomerate be assigned to the Animike? I have already, in speaking of the Kewatin series, given reasons for thinking the Ogishke conglomerate should be included in it. There are also reasons for suspecting it to be a part of the Animike. The dark colored argillytes into which we trace the beds of the conglomerate by strict continuity, bear strong resemblance to the slates of Gunflint lake. If we pass northward from Kekequabic, across the strike of the region, we come upon the Knife lake siliceous argillytes, which resemble the more characteristic siliceous argillytes of the Animike. These slates are also locally ferruginous, and the jaspilitic banded example illustrated in figure 20, is supposed to have been derived from the Knife lake slates—though this is only a conjecture. This example bears a striking resemblance to the jaspery schists on the north shore of Gunflint lake. A similar loose piece, less contorted, was seen between Epsilon and Kekequabic lakes. This is illustrated in figure 60. The presumption is that this was derived from Animike. Kewatin slates are near on the north, but they are argillaceous and porphyrellitic.

Again, the slates involved in the Ogishke conglomerate appear to lose their steady verticality in the region of Agamok, and the north shore of Gabimichigama. It is possible that this is the region of passage from the flat-lying schists of Gunflint lake to the vertical schists of Knife lake.

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[*] This in fact, has already been suggested by Irving and by Hunt.

In addition, it may be mentioned that the peculiar rock known in our survey as muscovado, is found on the southern shore of lake Gabimichigama (where sometimes it is micaceous), and something similar on an island in Illusion lake (XV Rep., p. 145). In these regions, the vertical Kewatin has not been certainly identified. On the other hand, muscovado of similar character is found at several points already mentioned, and at some of them it appears to be an upper bed of the Animike. I have already recorded my readiness to admit that it represents the Animike on lake Gabimichigama.

The objections to these views which present themselves to my mind are as follows: 1. The evidence already cited, that the Ogishke slates and conglomerates are embodied conformably in the great mass of the Kewatin series. 2. The fact that the Kewatin series in the region of Vermilion lake includes conspicuous siliceous and jaspilitic, as well as ferruginous, layers. These are fully described and illustrated in the fifteenth annual report. 3. If the Ogishke slates are a part of the Animike, they carry with them the vast series of slates on the north, into which they pass by transitions and intercalations which proclaim a historic continuity. But most of these northern schists would not be claimed for the Animike. In fact, the northern porphyrellytes are not distinguishable from the porphyrellytes of Gunflint lake, which lie discordantly beneath the Animike. 4. If the Animike slates change, in the neighborhood of Ogishke-muncie lake, from a gently inclined, to a vertical position, it is inexplicable that in Epsilon lake, two miles northwest of Ogishke-muncie, the Animike slates should be found again with an inclination in the same direction as they show at every other point in Minnesota. 5. Even if the thin edge of the Animike reaches as far as Gabimichigama, it will be observed that it appears to lie in a horizontal position upon the obscure edges of an older series, which probably represents the Kewatin. Its presence, therefore, would not help to the identification of the Ogishke conglomerate with the Animike.

5. *Eruptive rocks.* On this subject I am not prepared to offer many generalizations. I wish to exclude from this connection most of the granitoid and gneissoid rocks, as well as the crystalline schists, and the chloritic and sericitic schists. It is very evident that heat has played a most important part in the geologic history of the region, but in conceding the enormous influence of thermal agencies, I feel constrained to assume a somewhat conservative position.

(1) The great gabbro flood. I agree fully with American geologists in assigning a primitive molten condition to the sheet of gabbro which covers so many hundreds of square miles in the northwest. But its wide extent, considered as a molten flood, is a fact which excites amazement. My own observations have traced it over an area of twenty townships, or 720 square miles. In the surveyed and platted portion of Minnesota, west of the Grand Portage Reservation, it is reported as covering an area of thirty-two townships, or 1,152 square miles. There are about seven townships more in which the surface is occupied by more recent eruptives, which, in all probability, overlie a sheet of gabbro; giving us a total of thirty-nine townships, or 1,400 square miles, once, in the history of the state, covered by a glowing flood of molten rock.

The upper surface of the gabbro sheet lies at the present time at elevations very different at different points. While we must conclude that the surface over which it poured had already undergone vast erosions at the epoch of the gabbro outburst, it becomes, to my mind, more and more probable that great upheavals of the earth's crust have been suffered since the epoch of the outburst. I incline to think this the explanation of the saw-teeth configuration of the vertical section from north to south. There must have been, then, an action analogous to that which produced the famous "monoclinals" in the geology of the plateau region of the continental interior. At what epoch since the gabbro outflow the disturbance took place, I know no means of determining. It may have been geologically late. In considering the erosive retrocession of some of the cliffs, I have been impressed with the incompleteness of the work which has been begun, and apparently only begun. I am prepared to believe that the dislocations of the country do not antedate the continental glaciation.

In their physiognomy, the gabbro masses present a rude resemblance to basalt. Though the columnar structure is exceedingly incomplete, it becomes a conspicuous feature under the influence of perspective. Distance smooths and completes the rude and ill defined figures which rise like a colonnade from the cornices of the lofty structures reared by hundreds of regular horizontal courses of stone-work. From lake to lake, from ridge to ridge, these mimic forms succeed with such uniformity and impressiveness, that even the geologist begins to fancy himself wandering among the ruins of some desolated ancient city.

Scarcely any other structure is discernible in the gabbro mass. At times indications appear of the existence of imbricating layers having a gentle dip, as if the fluid rock had swept over the country in successive tides. For the greater part, the rock is massive in aspect except along the faces of the crowning cliffs. This is particularly the case with the occurrences along the northern shores of the lakes. Except, when weathered, the gabbro is solid and tough; but in some regions, as around Ima and Frazer lakes, entire exposures lie in a rusted and crumbling condition. A similar condition is seen in the high cliffs at the west end of Loon lake

In texture the gabbro is characteristically coarse. Sometimes some of the constituent minerals are half an inch in diameter. From this they graduate down to an extreme degree of fineness, so that it becomes impossible to decide macroscopically whether the rock is a gabbro, a noryte, a diabase, or only an altered condition of a contiguous formation.

No thorough examination has been made by me of its mineral constitution. Macroscopically, there is generally no difficulty in determining the presence of dark labradorite, lamellar augite and magnetite. In some regions olivine is not only conspicuously present, but forms a large percentage of the mass. The most noteworthy instance of this kind is in a knob on the north side of Pigeon river, rock 768-9, a few miles west of the Grand Portage. In some regions, a reddish feldspar is present, and this often occurs in crystalline grains, giving the formation a porphyritic character. This condition prevails along the north side of Loon lake. At the western end of this lake, the reddish feldspar weathers white, and the high cliffs present a brilliant appearance in the sunlight. In this vicinity much of the iron in the gabbro has undergone peroxidation, and the surfaces of cliffs have a rusted appearance, suggesting the approach to a mine of hæmatite. Red feldspar in smaller grains is met with along the north side of Animike bay of Gunflint lake, and several other points.

Magnetite is a constituent universally present. It generally exists in separable grains or crystalline forms. Sometimes however, it increases in abundance, and becomes a sort of cellular, hard, black groundmass. Still again, it usurps almost completely the place of the other minerals, and the gabbro becomes essentially a solid, black mass of magnetite. It is seen in this condition at one or two points on the north side of Iron or Mayhew lake, and is said to occur similarly on Pewabic and Tucker lakes. This magnetite, however, is shown by chemical analysis to be highly titaniferous. For further particulars, the reader may refer to § 27.

There is little probability that the flood of gabbro escaped through a single fissure. At several points it has been seen forming dikes.

At Partridge falls, on Pigeon river, a dike of gabbro appears to be connected with the gabbro overflow.

(2) Diabase, noryte and porphyry. Proper eruptive porphyry is found at several places. The most extensive as well as the most characteristic occurrence observed by me is found south of the western end of Epsilon lake. It appears first near the point of the lake, in alternation with a noryte-looking eruptive, but is traced southward a distance of half a mile, where it rises in a knob about 200 feet above the lake, which I named Grant's peak. It overlooks Kekequabic and several other lakes, and is a mile east by north from Mallman's peak. The porphyry where first observed, has a purplish groundmass, and contains green lamellar crystals. Near this, the lamellar crystals become fewer, and the base is replete with green amygdules which, farther on, constitute temporarily most of the formation, but still with some whitish groundmass. In this vicinity, flowage lines are very apparent. The great mass forming the peak is a purplish amygdaloidal porphyry. The porphyritic eruption appears to exist in other smaller knobs rising in the vicinity.

Near the south end of Moose lake (the one in T. 64-9W) rises a bold precipitous knob of erupted matter, consisting of rather coarse crystals and fragments of labradorite and augite without magnetite or olivine. This I have provisionally recorded as noryte. The gabbro already described in places appears destitute of magnetite, and seems to approach the condition of noryte. It is finer than the well developed gabbro, and holds a place near the bottom of the gabbro mass. For the latter reason it might be presumed that magnetite is present in small quantity, and that the rock is merely a variety of gabbro.

The dikes of the country are almost universally of diabase, if one may decide on macroscopic inspection. But they present an endless diversity of conditions. They are rather fine-grained, and sometimes almost aphanitic. Generally they occupy fissures with definite walls. The contiguous rock is sometimes greatly altered in the usual way but many times the alteration, even in argillyte, is very slight. The attitude of the dikes is almost always nearly vertical; but I saw one on the IVth Arm of Knife lake (rocks 947-52) dipping 30° N. N. E I have not discovered any system in the direction of trend. Occasionally, a dike has seemed to be of a dioritic character. This I noticed most particularly on some of the islands in Burntside lake (XV Rep. P 44).

The petrographic investigation of the eruptive rocks of my field is an important work, mostly remaining to be done.

6.—*Vein rocks.* Most of the rocks which I am led to class as veins appear to me to have had a non-eruptive origin. The majority of them are granulitic in mineral nature, consisting of quartz and orthoclase. Often one or the other is deficient in quantity. Frequently a small percentage of mica is present; and sometimes the vein consists of good granite. Veins of this class are apt to be tortuous, and some of them are surprisingly so. They seldom exceed four inches in diameter, and generally are less. They abound in the vicinity of the passage of gneiss into the crystalline schists. They do not maintain a uniform width for any considerable distance, like the dikes, but rapidly diminish and disappear. Unlike the dikes they exhibit many ramifications. In some cases, these are so numerous as to give the formation a reticulated structure. Many veins are filled with pure white quartz. The larger ones, which attain a breadth of over two feet, pursue somewhat persistent courses, but they are not much inclined to branch. Sometimes quartz veins of slender diameter are seen intersecting beds of schist in many directions in a reticulating fashion; and sometimes I have traced a transition from an earthy schist to a granulitic or quartzitic rock effected simply through the excessive abundance of small interlacing quartz veins. Compare XV Rep., p. 136.

Within my observations, veins of quartz carry few metallic compounds except pyrites. In several cases, this mineral has been explored, and even mined, in the belief that silver or gold would be found associated; but all such enterprises are now abandoned. Active work however, is carried on in T. 64-3E., upon a quartz vein said to carry silver, and believed to have been worked by a prehistoric race. See further, § 21 of this report.

§ 36.—SYSTEMATIC RESULTS OF THESE ARCHÆAN FIELD-STUDIES.

1. *Horizons of geologic discontinuity.* The most recent formatio embraced in the field which I have investigated is that above designated the Animike series. This beyond question, represents th characteristic portion of the Huronian, as defined by the Canadia geologists from the typical region north of lake Huron.* With equa

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* Undoubtedly, I think, the Canadian geologists also named as Huronian, rocks in other regions o very different character, and holding a different position in the general series. The only circumstanc justifying the identification, apparently, was their superposition on beds of a crystalline character. have maintained that the beds normally subjacent to the typical Huronian are simply deficient, nort of lake Huron, but make their appearance upon the shores of lake Superior, where they were mistak only parallelized with the Huronian of lake Huron. Precisely the same approximation of the Animik and gneiss exists at the west end of Gunflint lake, and continues westward along the south flank of th Giant's range. The phenomena here and in Canada are explained by the supposition of a progressiv subsidence of the granitic regions during the deposition of the Animike

certainty, the Animike does *not* rest directly on crystalline schists and gneisses. It rests on another, older-looking series of schists, standing vertically, and presenting an enormous unconformability; this shows the occurrence of events in the interval between the two series, of such transforming and revolutionary character as are generally held to separate two geologic ages and two systems of strata. The petrographic contrasts of the two series have the same significance. The economic products are similarly contrasted. The Animike series embraces great beds of magnetite; the older series, great beds of hæmatite and limonite. The members of the Animike series are all conformable in stratification, and appear to belong to one age, with its varying conditions of sedimentary accumulation.

If the older looking schists below are systemically detached from the Animike by a mechanical break, they are not less certainly detached from the still older crystalline and foliated beds by a mineralogical break which expresses a profound change in the conditions of chemical activity, and thus implies a break in the tenor of geologic history, which must have been also of a revolutionary character. It appears necessary to isolate the hæmatite-bearing beds from the crystalline schists as well as from the Animike. Thus is a stratigraphic system disengaged and delimited with the distinctness and certainty, which we must for convenience designate by a name. The term Kewatin, which I have provisionally employed, was not proposed in a sense so restricted, but embraced, with newer strata, the entire series of crystalline schists. It is probable that some one of the numerous names proposed by geologists for supposed divisions of Archæan or Eozoic rocks, may prove to have the same extension as is here given to the system immediately subjacent to the Animike or Huronian. It is quite possible also, that an older term will be found, covering the range of strata embraced in the actual and original Huronian. In this connection, I will not attempt to decide, but employ provisionally the term Huronian now so well understood. For the subjacent system I will employ also provisionally, the term *Marquettian;* but, if another name proves hereafter to be equivalent, I hope the term here suggested will never be cited as a synonym; for of synonyms the excess is already burdensome. As to the known rocks older than the Marquettian, they are united in one division by their common crystalline character, and by their structural conformity. That real unbedded granites and syenites exist I have no reason to doubt, but they are not embraced in the field here reported on. Even when found, I should feel led to connect them in geological history with the gneisses, and embrace them in the same system. For this lowest and crystalline system the term Laurentian has been employed, and I will here use it—also provisionally.

Undoubtedly, in the physical history of the earth's crust, other and older terranes have existed and disappeared—or perhaps even still exist; but they are for the present subjects of merely theoretical study, and of course, have no place in a report on facts of observation.

2. *Succession and subordination of terranes.* These views, presented in their application to Minnesota, are summarized in the following table:

HURONIAN SYSTEM. (Compare §2 of this report). Over 4,082 feet.
Magnetitic Group. 32 feet.
Dark, laminated, shaly argillyte, sometimes magnetitic, 29 feet.
Magnetitic beds, often uppermost, 8 feet. Place of sideritic bed?
Muscovado, uppermost when the two above are wanting, 4 feet.
Siliceous Group. 50 feet.
Siliceous argillytes and siliceous and jaspery schists, 50 feet.
Argillitic Group. 4,000 feet.
Dark, laminated, shaly argillytes, over 4,000 feet in Minnesota.
(Bottom of the system not reached at contacts seen with gneiss and Marquettian).

MARQUETTIAN SYSTEM. 27,500 feet.
Ogishke Group. 10,000 feet, but local. (Perhaps half this).
Ogishke conglomerate, slaty and diabasic. 4,500 feet each side of synclinal.
Ogishke dolomyte, included in the conglomerate. 10 feet.
Conglomerate greenrock. 500 feet each side of synclinal.
Tower Group. (Earthy schists). 15,000 feet.
Sericitic and argillitic schists, with beds of hæmatite, 5,000 feet.
(These sometimes changed to chloritic schists).
(They pass eastward into schists prevailingly porphyrellitic).
Stuntz conglomerate, porodyte and porphyrel, 20 feet.
Graywacke Group. 2,500 feet.
Graywacke and hornfels.
Graywacke with indications of fine mica and hornblende ("Nascent mica schists.")

LAURENTIAN SYSTEM. 89,500 feet.
Vermilion Group. Over 1,500 feet.
Crystalline schists—micaceous, hornblendic, dioritic, granulitic.
Gneissic Group. Over 88,000 feet.
Chlorite gneiss. (Not universally developed).

Saganaga, White Iron and Basswood gneisses.

Thus the crystalline schists and gneisses fall entirely within the Laurentian system. There are no Huronian gneisses in Minnesota. We find nothing of "older" and "newer" gneisses. We find no "clay-slates" beneath the horizon of the crystalline schists. But I cannot deny the existence of a different state of things in other regions. To me it seems probable, however, that a comparatively undisturbed region, like northeastern Minnesota, must approach near to a normal exhibit of the real succession of the Archæan rocks.

§ 37. SOME VIEWS ON PRIMITIVE GEOLOGIC HISTORY.

In concluding my report for 1886, I recorded some statements indicating my tendency, on a provisional interpretation of the observations then completed, to ascribe a more important agency to metamorphism, in the history of Archæan rocks, than it had been customary for German students of geognosy and petrography to admit. I have now extended my field studies of rocks of this age over another season; and I confess I have not discovered reasons for renouncing the opinions heretofore shadowed forth. The facts stated and illustrated in my former report still exist; and many more facts of the same tenor have been noted during the season of 1887. While I cannot appropriately enlarge, in this place, upon the bearing of these facts, I desire to emphasize the conviction that nearly all the bedded terranes of northeastern Minnesota have been once marine sediments; and have reached their present conditions through the action of molecular, and to some extent, mechanical forces, in the presence of heat, water and natural re-agents.

As to the eruptive origin of the hæmatites and associated jaspilytes, the evidences of it are so slender that the doctrine would only excite my wonder, if it were not held by a few geologists of good reputation. The difficulties of that view are many, but I must embrace another occasion to set them forth. As to the eruptive nature of certain chloritic and sericitic schists, I have already said enough to give expression to my present dissent. But I wish to be understood as holding the question open for further evidence. The gabbros, norytes, diabases and dolerytes I freely admit to have reached the surface in a state probably molten. The crystalline schists appear to me to have been original sediments which have been partly decomposed and fixed in new combinations while in a semi-plastic state occasioned by heat nd alkaline waters. In the gneisses, the same class of changes appears to me to have been carried further. Even here, the impress of original stratification is retained. I have no reason to doubt, however, that terranes exist in which these changes have proceeded so far as to obliterate all traces of original stratification. Such a result would require the attainment of a condition of semi-fluidity such that pressure—of steam, gases or crustal movements—would readily squeeze the product into fissures through the less softened strata, or into spaces between them. Thus would result the phenomena of granitic veins without the necessity of postulating a deep molten source for any of the older granites.

I repeat the conviction heretofore expressed, that probably none of our granites, viewed as changed sediments, represent the oldest sedimentation on the globe. It is puerile to imagine that the history of the world has not been long enough, and its early epochs revolutionary enough to have transformed and blotted from recognition the earliest deposits of the ocean. More puerile is the fancy that in the widespread areas of granite and gneiss nature has preserved patches of the original fire-formed crust of the planet. Equally inadequate, it seems to me, is the opinion that these granitic patches are cooled outbursts from a molten interior, through a crust either sedimentary or igneous in origin. Such views belong to the infancy of the science, and survive only in conservative minds A present crystalline condition is a fact which bears on the mineralogical relations of a rock, but of itself sheds no light on rock-histories. It testifies to a present fact, not to a past genesis. Of the latter a wider range of evidence must speak. The revelations of the polarized ray are almost a work of magic, but there is danger of over-estimating their significance. Petrographic studies possess too much interest and value to be weighted with the responsibility of sanctioning theories of general geogony which demand the widest possible range of investigation, under the guidance of broad and many-sided intelligence.

Mem.—In connection with the conglomerate at Wonder island, in the Saganaga gneiss, see descriptions of the Obermittweida conglomerate described by various authors, especially by Professors Hughes and Bonney in *Quarterly Journal of the Geological Society* for Feb. 1, 1888, pp. 20-31, and the further citations there given.

APPENDIX I.

UE OF ROCKS WITH CORRESPONDING LOCALITIES.

[Localities are given more precisely in the report.]

BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
	Page.				
cke	19	Vermilion lake	20	62	15
cke slate	19	"	20	62	15
ke slate, thick	20	"	20	62	15
cke slate, thin.	20	"	20	62	15
ic graywacke slate.	20	"	20	62	15
e	20	"	20	62	15
ritically quartzose porodyte	20	"	20	62	15
schist	22	"	21	62	15
schist w. quartz grains	22	"	21	62	15
veins in graywacke schist	22	"	21	62	15
stem of dikes (so-called)	22	"	21	62	15
stem of dikes (so-called)	22	"	21	62	15
e (so-called).	23	"	21	62	15
ic felsyte	23	"	34	62	15
ritically quartzose porodyte	23	"	34	62	15
te (so-called)	23	"	34	62	15
gitic sch. w. fels and q	23	"	34	62	15
t graywacke	23	"	3	61	16
cke.	24	"	3	61	16
schist	26	"	6	62	14
c sericitic schist	26	Mud creek and lake	5	62	14
schist with rusty blotches	26	"	5	62	14
cke	27	"	5	62	14
se porphyry	27	"	3	62	14
porphyry	27	"	3	62	14
, bluish, fine compact	27	"	3	62	14
syte-like.	27	"	3	62	14
yte-like	27	"	3	62	14
c sch. very irregular	27	"	3	62	14
porphyry	28	"	3	62	14
cke, compact	28	"	12	62	14
hæmatite	28	Sand lake	13	62	14
cke, partly chloritic	29	"	14	62	14
cke, massive, chloritic.	29	"	14	62	14
cke, massive, metallic	29	"	14	62	14
asper schist.	29	Armstrong river	..	..	..
ic schist, dark	29	"	..	..	..
cke, epidotic w. heulandite	30	Eagle Nest lake	22	62	14
cke, ferruginous	30	"	22	62	14
c schist, compact	30	"	24	62	14
ic sericitic schist	30	"	24	62	14

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.
		Page.	
41	Chlorit. ser. sch., compact	30	Eagle Nest lake
42	Chlorit. ser. sch	30	"
43	Ser. sch. jaspery, ferruginous	31	"
44	Ser. or damourite schist	31	"
45	Chlor. ser. sch. with q. and f	31	"
46	Ser. sch. soft portion	31	"
47	Petrosilex and felsyte, bedded	31	"
48	Ser. sch., granular, compact	32	"
49	Quartzitic ser. sch., thick-bed	32	"
50	Chlor. ser. sch. w. pyrites	32	"
51	Ser. sch., thin laminated	32	"
52	Quartz vein, ferruginous	32	"
53	Pyrites in quartz	32	"
54	Epidotic graywacke sch	33	"
55	Epidote crystallizing	33	"
56	Chloritic sch., heavy-bed	34	"
57	Chloritic sch. forming vein	34	"
58	Labradorite? chiefly	35	"
59	Ferruginous jasper	35	"
60	Quartz porphyry	35	"
61	Graywacke mica schist	38	Creek to Burntside L
62	Granite vein	38	"
63	Graywacke mica schist	39	Burntside lake
64	Mica sch., fine, compact	39	"
65	Mica schist	39	"
66	Mica schist	39	"
67	Argillitic mica schist	39	"
68	Mica schist	39	"
69	Hornblende sch., massive	42	"
70	Dike in hornblende sch.	42	"
71	Hydromica granite	43	"
72	Granite	44	"
73	Hornbl. sch. in granite	44	"
74	Dioryte	45	"
75	Dike matter	44	"
76	Compact dioritic sch	52	"
77	Hydromica schist	52	Burntside river
78	Graywacke	52	"
79	Hydromica schist	52	Long lake
80	Fibrous hydrom. sch. in dike	52	"
81	Sericitic sch., greenish.	53	"
82	Fine dioryte?	53	"
83	Dioritic schist	53	"
84	Ser. sch. porphyrit, w. h.	4	"
85	Argillyte	54	"
86	Sericitic schist	54	"
87	Chloritic argillyte	54	"
88	Ser. sch., smooth, leather colored	55	"
89	Ser. sch., finely mottled	55	"
90	Argillyte	55	"
91	Chloritic graywacke	55	"
92	Argillyte	55	"
93	Graywacke.	68	Head of rapids, Fall R
94	Graywacke	68	Garden lake
95	Graywacke	70	"

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page.				
96	Chlor. sericitic schist	70	Garden lake	28	63	11
97	Sericitic schist	70	"	28	63	11
98	Sericitic schist	70	"	28	63	11
99	Chloritic graywacke, w. red m.	70	"	27	63	11
100	Quartz	70	"Silver City"	29	63	11
101	Sericitic mica schist	71	Garden lake	32	63	11
102	Micaceous hornblende sch.	71	"	32	63	11
103	Hornblendic magnetic sch.	71	"	32	63	11
103b	Nascent mica schist	74	White Iron lake	32	63	11
104	Granulyte vein	74	"	32	63	11
105	Biotite syenite	74	"	32	63	11
106	Syenite w. fragments of h. sch.	74	"	32	63	11
107	Syenitic gneiss	75	"	31	63	11
108	Syenite with vein	75	"	31	63	11
109	Syenite, much red orthocl.	75	"	31	63	11
110	Muscovite schist	75	"	6	62	11
111	Muscovite schist	75	"	6	62	11
112	Syenite w. glassy feldspar	75	"	1	62	12
113	Hornblendic? (augitic?) mic. sch.	76	"	12	62	12
114	Augite or chlorite rock	76	"	12	62	12
115	Syenite w. glassy feldspar	76	"	12	62	12
116	Augite rock	76	"	12	62	12
117	Red syenite w. vein of syenite	76	"	25	62	12
118	Syenite gneiss	77	"	12	62	12
119	Muscovit. hornb. sch. and syen.	77	"	12	62	12
120	Syenite	79	"	6	62	11
121	Biotitic quartz diabase	79	"	6	62	11
122	Biotitic diabase w. orthocl.	79	"	6	62	11
123	Biotitic syenite	79	"	6	62	11
124	Felsitic and earthy rock	79	"	6	62	11
125	Felsitic and earthy rock	79	"	6	62	11
126	Micaceous graywacke schist	80	"	32	62	11
127	Felsitic hornblendic sch.	72	Garden lake	20	63	11
128	Sericitic siliceous schist	72	"	20	63	11
129	Mica schist	73	"	28	63	11
130	Diabase from dike	81	Farm lake	3	63	11
131	Porphyritic syenite	81	"	3	63	11
132	Black mineral	82	"	34	63	11
133	Porphyritic mica schist	82	"	34	63	11
134	Hydromica schist	89	"	34	63	11
135	Porphyry (porphyrel?)	73	Garden lake	21	63	11
136	Banded jaspilyte	69	Near Garden lake	30	63	11
137	Best iron ore	69	"	30	63	11
138	Chlorite rock	......	Falls of Fall R.	17	63	11
139	Sericitic schist, black cryst.	66	Fall lake	18	63	11
140	Felsitic schist	60	"	17	63	11
141	Sericitic schist	62	"	16	63	11
142	Sericitic schist, greenish grains	64	"	9	63	11
143	Sericitic schist	64	"	9	63	11
144	Sericitic argillyte	62	"	10	63	11
145	Sericitic argillyte	62	"	11	63	11
146	Sericitic schist	62	"	11	63	1
147	Sericitic schist	62	"	2	63	11
148	Sericitic pseudo-conglomerate	62	"	36	64	1
149	Sericitic schist, chloritic spots	63	"	35	64	11

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.
		Page.	
150	Sericitic schist, yellowish	66	Fall lake
151	Sericitic schist, blue	66	"
151*b*	Sericitic chloritic schist	66	"
152	Chloritic schist	56	Long lake
153	Petrosilex	56	"
154	Wackenitic chlorite schist	57	"
155	Augite (chiefly)	57	"
156	Biotite granite	45	Burntside lake
157	Hydromica granite	45	"
158	Noryte	45	"
159	Granite	46	"
160	Interbedded granite and dioryte	46	"
161	Bedded dioryte	46	"
162	Micaceous hornblende schist	46	"
163	Diallage?	47	"
164	Granite with green feldspar	48	"
165	Mixture of biotite and augite	49	"
166	Diallagic biotite schist	49	"
167	Biotite hornblende schist	50	"
168	Dioryte	50	"
169	Masses of hornblende	50	"
170	Mic. sch. and granulyte interbedded	50	"
171	Dioryte schist	51	"
172	Large crystals of orthoclase	51	"
173	Coarse Muscovite gneiss	51	"
174	Compact sericitic schist	94	Saturday lake
175	Sericitic chloritic argillyte	94	"
176	Siliceous sericitic argillyte	94	Urn lake
177	Doleryte	94	"
178	Amygdaloid	94	"
179	Porphyritic granulyte	95	"
180	Fine mica schist	95	Portage
181	Hornblende schist	95	Basew'd (Bassi-menan) L
182	Syenite—two varieties	97	"
183	Graywackenitic mica schist	98	"
184	Mica sch. passing to gneiss	98	"
185	Mica sch. w. colored bands	98	"
186	Syenite	99	"
187	Syenite w. crystallized hornbl. (see corrections and additions)	99	"
188	Syenite	99	"
189	Hornblende schist	99	"
190	Transition from syenite to schists	100	"
191	Argillyte	120	"
192	Argillitic sericitic schist	121	Carp lake
193	Sericitic argillyte	121	Newfound lake
194	Argillitic sericitic schist	122	"
195	Graywacke schist	122	"
196	Chloritic sericitic schist	122	"
197	Diabase from dike	123	Moose lake
198	Ser. sch. from contact w. dike	123	"
199	Sericitic slate	123	"
200	Diabase	123	"
201	Argillyte	123	"
202	Chloritic sericitic schist	124	"

APPENDIX I.—Continued.

BRIEF DESCRIPTION.	Report, 1886	REGION.	Sec.	Town	Range.
	Page				
hyritic diabase	125	Snowbank lake	33	64	9
ase	125	"	27	64	9
ite	126	"	35	64	9
ite	126	"	35	64	9
te w greenish hornbl	127	"	31	64	8
compact gneiss	127	"	31	64	8
compact gneiss	127	"	31	64	8
bedded gneiss and hornbl. sch	127	"	31	64	8
wackenitic mica sch	128	"	29	64	8
wackenitic mica sch	128	"	29	64	8
schist	128	"	29	64	8
ite	128	"	29	64	8
s	128	"	29	64	8
coarse syenite	128	"	29	64	8
wackenitic chlor. sch	128	"	29	64	8
schist, very fine	129	"	20	64	8
wacke schist	130	"	19	64	8
yte schist	130	"	19	64	8
s	130	"	19	64	8
itic hornblendic schist	131	Boot lake	20	64	8
tic schist	131	"	21	64	8
itic schist	131	"	16	64	8
itic schist	133	Ensign lake	15	64	8
pact argillitic schist	133	"	15	64	8
, laminated argillyte	133	"	15	64	8
llitic sericitic schist	134	"	16	64	8
llitic sericitic schist	134	"	17	64	8
itic schist	134	"	17	64	8
ic schist (poroditic?	134	"	8	64	8
itic felsitic schist	134	"	8	64	8
itic sericitic schist	136	"	8	64	8
t in contact with dike	136	"	9	64	8
yte in the above schist	136	"	9	64	8
ite in schist 565	136	"	9	64	8
ritic sericitic schist	136	"	9	64	8
ion of quartz and schist	136	"	9	64	8
ritic sericitic schist w. q. grains	137	"	9	64	8
llyte and quartz	137	"	8	64	8
itic argillyte	134	"	7	64	8
lyte	135	"	8	64	8
itic sch. and lamina of q	137	"	9	64	8
ted sch. w. q. laminæ	137	"	9	64	8
sch, w. q. and fels. grains	138	"	10	64	8
llyte w. q. grains	138	"	10	64	8
tic argillyte	138	"	10	64	8
elly sericitic schist	138	"	10	64	8
ase from dike	139	"	11	64	8
z and black argillyte	139	"	11	64	8
ase from dike	140	"	15	64	8
lyte, fine, dark	142	Sucker lake	34	65	8
material (peculiar)	121	Carp lake	1	64	9
rite rock	102	Newton lake	34	64	11
nitic, siliceous sericit. sch	102	"	34	64	11
nitic sericitic, schist	102	"	34	64	11
itic schist	102	"	34	64	11

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	Region.
		Page.	
256	Sericitic sch. w. shining scales	103	Newton lake
257	Nascent mica schist	103	“
258	Syenitic gneiss	104	Pipestone falls
259	Syenitic gneiss	104	“
260	Graywacke schist	104	“
261	Magma of gneiss	104	“
262	Rock 261 in contact w. gneiss	104	“
263	Micaceous hornblende schist	104	“
264	Micaceous hornblende schist	105	Basswood (or Bassi-menan) L.
265	Uralitic syenite	105	
266	Chlorite granite	106	“
267	Menaccanitic hornblende sch	106	“
268	Chlorite schist	106	“
269	Chlorite gneiss.	106	“
270	Syenite gneiss with chlorite	107	“
271	Chlorite schist	107	“
272	Chloro-syenitic gneiss	107	“
273	Mica-hornblende schist	107	“
274	Gravelly chlorite rock	107	“
275	Mica schist	108	“
276	Dioryte. (also rock 524, Rep. 1887, p.196)	108	“
277	Menaccanitic schist.	109	“
278	Muscovite granite (silvery m.)	114	Crooked lake
279	Dioryte (lamellar hornbl.)	115	“
280	Dioryte schist	117	“
281	Dioryte schist.	117	“
282	Biotite schist	117	“
283	Biotite gneiss	117	“
284	Decaying gneiss	118	“
285	Biotite gneiss	118	“
286	Red biotite gneiss	118	Iron lake
287	Biotite gneiss	119	“
288	Biotite muscovite schist	119	“
289	Distinctly bedded gneiss	119	“
290	Quartz, feldspar and mica	119	“
291	Muscovite chlorite gneiss	119	“
292	Chloritic sericitic schist	60	Fall lake
293	Diabase from dike.	60	“
294	Chloritic sericitic schist	110	Basswood or Bassi-menan L.
295	Noryte	145	Ima lake
296	Transitional doubtful rock	145	“
297	Transitional rock.	145	“
298	Gabbro, fine	146	Thomas lake
299	Fine-grained gabbro	146	“
300	Formative gabbro	146	“
301	Gabbro	146	“
302	Chloritic gneiss	149	Kekequabic lake
303	Compact chloritic gneiss	149	“
304	Compact chloritic gneiss	149	“
305	Chloritic porphyrel	150	“
306	Argillitic slate	150	“
307	Conglomerate.	150	“
308	Porphyritic diabase schist	151	“
309	Porphyritic diabase	151	“
310	Dark siliceous slate	151	“

APPENDIX I.—Continued.

BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
	Page.				
-colored slate, softer	151	Kekequabic lake....	30	65	6
-rock across slate	151	"	30	65	6
. hard, bluish slate.......	152	"	32	65	6
llyte.......	157	Ogishke Muncie lake	28	65	6
hyrel....	157	"	28	65	6
hyry	157	"	28	65	6
ase?	157	"	28	65	6
glomerate	159	"	28	65	6
hyritic conglomerate	159	"	28	65	6
asic groundmass of congl...........	159	"	28	65	6
, micaceous argillyte.......	159	"	28	65	6
and granular rock...........	159	"	28	65	6
with pebbles	159	"	28	65	6
glomerate ill defined	159	"	28	65	6
k siliceous argillyte (see corrections d additions)	160	"	27	65	6
asic groundmass.	162	"	23	65	6
and groundmass.	162	"	23	65	6
n, diabasic groundmass.......	162	"	23	65	6
asic groundmass....................	162	"	23	65	6
citic schist.........................	162	"	23	65	6
citic chloritic schist................	162	"	23	65	6
citic, 1st gradation	162	"	23	65	6
citic, 2d gradation	162	"	23	65	6
citic, 3d gradation	162	"	23	65	6
phyritic schist......................	164	"	26	65	6
een rock"	165	"	35	65	6
en rock, from summit...............	165	"	35	65	6
phyritic rock....	165	"	26	65	6
ptive rock	161	"	26	65	6
e	161	"	26	65	6
phyritic, but gravelly...............	166	"	22	65	6
enstone conglomerate................	166	"	22	65	6
phyry pebble	166	"	22	65	6
phyritic matrix	166	"	22	65	6
velly matrix	166	"	22	65	6
enstone (like 342) columnar.	166	"	22	65	6
pted rock	168	Gabimichigama lake.	25	65	6
nty slate	169	"	25	65	6
ywacke-like.	170	"	36	65	6
scovado-gabbro?.....	170	"	36	65	6
ywacke-like.................. ...	170	"	1	64	6
ssive graywacke.............. ..	170	"	1	64	6
aceous gabbrolyte?...	170	"	1	64	6
bro..............	171	"	12	64	6
bro	171	"	12	64	6
brolyte	171	"	1	64	6
d of iron-bearing rock..............	171	"	1	64	6
eritic? rock........................	171	"	6	64	6
phyrel	158	Zeta lake............	28	65	6
phyrel	153	Kekequabic lake....	29	65	6
phyrel..............................	153	" ...	29	65	6
phyrel	152	" ...	29	65	6
ywacke-like.........................	152	"	30	65	6
e-rock	153	"	31	65	6

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886. Page.	REGION.	Sec.	Town	Range.
364	Chlorite schist	153	Kekequabic lake	31	65	6
365	Porphyrel	153	“	36	65	7
366	Green rock	153	“	36	65	7
367	Chloritic conglomerate	154	“	36	65	6
368	Green, conglomeritic sch	154	“	34	65	7
369	Green, conglomeritic sch	154	“	34	65	7
370	Fine, reddish, granulitic sch.	155	“	3	64	7
371	Granulitic schist	155	“	3	64	7
372	Gabbroloid rock	155	“	4	64	7
373	Gabbroloid	155	“	3	64	7
374	Gneissic rock	155	“	3	64	7
375	Chloritic gneiss	155	“	2	64	7
376	Subgranular felsyte	156	“	2	64	7
377	Felsitic schist	149	“	3	64	7
378	Porphyritic gneiss	149	“	2	64	7
379	Green-rock and granulitic	149	“	2	64	7
380	Chlorite gneiss.		“	2	64	7
381	Porphyrel		“	36	65	7
382	Porphyrel	150	“	36	65	7

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page.	REGION.
383	Fine red quartzyte (Port Finley)	145	Port Finley, Canada.
384	Diabase	145	Bruce mines, Canada
385	Diabase	146	“
386	Diabase		“
387	Quartz from copper vein		“
388	Limestone		“
389	Diabase slate, fine	147	Thessalon, Canada.
390	Same with chloritic lustre.	147	“
391	Diabase, average condition	147	“
392	Diabase slate, chloritic, etc	148	“
393	Quasi-amygdaloid	149	“
394	Diabasic slate w. amygdules	149	“
395	Gray quartzyte	150	1½ mile N.W.fromThessalon
396	Dark gray quartzyte	150	“ [Can.
397	Slate in quartzyte	151	“
398	Diabase in dike	151	“
399	Red quartzyte	151	“ [Can.
400	Diabase	151	2½milesN.W.from Thessalon
401	Quartzyte	152	3 miles N W. from Thessalon
402	Diabase	152	5½milesN.W.from Thessalon
403	Diabase	153	“ [Can.
404	Quartzyte	153	“
405	Quartzyte, greenish, fine	154	2 miles N. from Thessalon.
406	Quartzyte, red, conglomeritic	154	¾ mile from Ansonia, Can.
407	Diabase	154	“
408	Quartzyte, red	156	Near Ansonia. Can.
409	Yellowish, cherty limestone.	156	“
410	Pinkish, cherty limestone		“

APPENDIX I.—Continued.

BRIEF DESCRIPTION.	Report, 1887	REGION.
	Page.	
iated diabase	155	At Ansonia, Can.
diabase		
ase	161	Blind river, Can.
quartzyte	161	"
ase, pale green feldspar	162	
ase, pink feldspar	162	
ase, lamellar augite	162	
ous slate	161	Blind river, Can.
te-like, red feldspar	163	"
, becoming dioritic	163	"
, completely dioritic	163	"
ritic shale fr. joint	163	"
itic mass	......	
tzyte, gray and red	163	Blind river, Can.
etrosilex	163	"
ase	163	"
	163	"
ase	156	1 mile W. of Ansonia, Can.
par	156	"
of	156	S.W.¼ sec. 8, Lefroy, Can.
, more slaty	....	
te slate	......	
ase slate	......	[Can.
y felsyte	157	½ mile S. W. from Ottertail,
pathic slate	156	20 rods S. of Ottertail, 4-cor's
ulyte from a pebble	......	[Can.
te	158	Near Ottertail, Can.
ty limestone	.....	Valley of Thessalon, near
ty limestone (organic?)	158	Thessalon, Canada.
te	158	2 miles N. from Ottertail, Can.
ike slate	159	2 miles S. from Murray's Cor-
te becoming granulyte	159	ners, Can. "
te	159	"
inclosing pebble	159	Murray's Corners, Canada.
atite in quartzyte	159	"
e slate	160	Two miles S. E. from Otter-
pink quartzyte	160	tail, Canada. "
ase, light blue.	155	Ansonia, Canada.
ty limestone, pale pinkish	155	"
ty limestone coarser	......	"
ase slate embraced in above	155	"
wish cherty limestone	155	"
p rock" of miners	172	Sec. 19, T. 47 27, Ishpeming,
passing to hæmatite	172	Mich. "
lomerate over hæmatite	172	Old Saginaw mine, Ish., Mich.
	174	1½ miles N. W. from "
tzyte	174	" "
itic slate	175	2½ " "
hyrel in contact w. same	175	" "
lomeritic schist	175	
ous dark band in same	175	At the bridge, Deer lake "
cal slaty rock	175	W. side of " " "
and red quartzyte	176	" " "
amorphous talc	176	2½ miles E. from Ropes gold
alline talc	176	mine. "

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page.	REGION.
466	Gold bearing quartz	176	Ropes gold mine.
467	Slate of the country rock		"
468	Sericitic lamina	176	2½ miles N. W. from Ish., M.
469	Green argillyte	177	Ishpeming, Mich.
469*a*	Green argillyte (analysis by Taft)	177	"
470	Ashen argillyte	177	"
470*b*	Ashen argillyte (analysis by Taft)	177	"
471	Specimens with Martite crystals	177	"
472	Quartzose chlorite schist	177	"
473	Dioryte (so-called)	177	Michigamme, Mich.
474	Granite (so-called)	177	1 mile N. Michigamme, M.
475	Quartzyte and granite in contact	178	" "
476	Greenstone dike in granite	178	" "
477	Lamina of sericitic matter	178	" "
478	Quartzyte	178	Near Michigamme, Mich.
479	Interlaminated sandst. and hæmat	178	Swan mine, Negaunee, Mich.
480	Chalcedonic silica and hæmat	178	" "
481	Jasper and hæmatite	178	" "
482	Quartzose chloritic rock	178	Buffalo mine, "
483	Slate	178	Near the " "
484	Black argillyte	178	" " "
485	Slate	179	" " "
486	Quartzyte, north-dipping	179	Iron Cliffs mine, "
487	Quartzyte	180	" "
488	Quartzyte	180	Near Teal lake, "
489	Talcose schist	181	Bluff street, Marquette, M.
490	Vitreous talcose schist	181	Bluff street, Marquette, Mich
491	Ambiguous, perhaps eruptive	181	"
492	Felsitic schist	181	Near lighthouse, " "
493	Porphyrel	182	Lighthouse point, " "
494	Sericitic felsitic schist	182	" " "
495	Schist, showing cross banding		" " "
496	Great greenstone dike		" " "
497	Altered schist with cross banding		" " "
498	Dike rock (east and west)		" " "
499	Brecciated mass		
500	Slate	186	N'r Colby mine, Bessemer "
501	Iron ore, Valley mine		Valley mine, " "
502	Syenite	187	N'r Aurora mine, Ironw'd "
503	Quartzyte	187	" " "
504	Black slate	188	½ mile E. Iron King m'n "
504*a*	Granulitic gneiss (pink)	189	Penokee Gap, Wis.
505	The dark rock	189	"
506	Same, with vein of felsyte	190	"
507	Dark and pink mixed	190	"
508	Nascent mica schist	190	"
508*a*	Porphyrelloid rock	190	"
509	Hornblende schist	190	"
510	Hornblende (?) rock	190	"
511	Quartzyte, w. some feldspar	191	"
512	Vitreous quartzyte	191	"
513	Quartzyte with crystals fels	191	"
514	Hornblende schist		"

APPENDIX 1.—Continued.

BRIEF DESCRIPTION.	Report, 1887.	REGION.
	Page.	
ceous schist	191	Penokee Gap, Wis.
ceous schist banded	191	"
ceous argillyte	191	"
citic argillyte	191	"
gnetitic siliceous schist	192	"
gnetitic schist	192	"
ck, carbonaceous argillyte	192	"
k speckled argillyte	192	"
ywacke, fine	195	Portage, Mud P'k to Burntside lake.

BRIEF DESCRIPTION.	Report, 1887.	REGION.	Sec.	Town.	Range.
	Page.				
rite rock—pipestone	108 (Rp '86) 196	Pipestone rapids	..	..	..
itic argillyte	196	Sucker lake.	32	65	8
ded jaspilo-hæmatitic	144 (Rp '86) 197	Knife lake.			
eous argillyte	198	"	27	65	7
ty argillyte	198	"	26	65	7
eous argillyte	198	"	26	65	7
nish bands in last	198	"	26	65	7
n a bowlder	198	"	26	65	7
asic schist	199	"	24	65	7
asic conglomerate	199	"	24	65	7
tic siliceous schist	199	"	19	65	7
asic slate and argillyte	199	"	20	65	7
, slaty argillyte	199	"	22	65	7
tz conglomerate	199	"	21	65	6
tz conglomerate	200	"	20	65	6
eous argillyte	202	"	17	65	6
wacke	203	"	18	65	6
wacke	203	"	18	65	6
graywacke	203	"	24	65	7
tz conglom. fr. bowlder	203	"	23	65	7
y argillyte	204	"	14	65	7
tz conglomerate	204	"	14	65	7
itic felsitic schist	204	"	14	65	7
hyritic Stuntz conglom	204	"	14	65	7
ious argillyte	204	"	12	65	7
ditic rock	204	"	12	65	7
dyte	205	"	7	65	7
dyte	207	"	6	65	6
dyte	208	"	32	66	6
-textured graywacke	210	Otter Track lake	32	66	6
ase	210	"	32	66	6
wacke	210	"	32	66	6
rite gneiss	210	"	28	66	6
wacke	210	"	33	66	6

APPENDIX 1.—Continued.

BRIEF DESCRIPTION.	Report, 1887, Page.	REGION.	Sec.	Town.	Range.
anaga syenite	217	Saganaga lake	4	66	4
anaga syenite	217	“ Canada.	34	67	4
nellar augite, coarse	222	“	34	67	4
nellar augite, fine	222	“	34	67	4
nellar augite, w. feldsp	222	“	34	67	4
gite, feldspar and epidote	222	“	34	67	4
t lamellar mineral	222	“	34	67	4
e green augite	222	“	34	67	4
gite hyposyenite (?)	222	“	34	67	4
enish, transparent augite	222	“	34	67	4
e 615, but pale green	222	“	34	67	4
anaga syenite w. pebbles	222	“	34	67	4
anaga syenite	223	“	22	67	4
nite from dike	223	“	22	67	4
anaga syenite	223	“	20	67	4
l fels. and chlor. horbl	223	“	20	67	4
ck syenite	223	“	20	67	4
base	223	“	20	67	4
n lamellar augite like 615	223	“	20	67	4
e 628	224	“	20	67	4
aceous gneiss	224	“	17	67	4
wing slatiness	224	“	6	67	4
re solid portions	224	“	6	67	4
wing the cleavage	224	“	6	67	4
wing warped parallel lam	224	“	6	67	4
artz from a vein	224	“	6	67	4
nite and chlor. syenite	224	“	6	67	4
tite gneiss	226	“	..	67	4
orite-augitic rock	226	“	33	67	4
stly lamellar augite	226	“	33	67	4
dspar and q. from dike	226	“	33	67	4
mation containing the dike	226	“	33	67	4
anaga syenite	227	Granite lake	27	66	4
anaga syenite	229	Boundary lake	36	66	4
anaga syenite	229	“	1	65	4
anaga syenite	232	“	12	65	4
eissic syenite (No. 822)	233	“	13	65	4
anaga syenite	237	Gunflint lake	13	65	4
gnetitic schist fragments	237	“	24	65	4
gnetitic graywacke	237	“	24	65	4
nty slate	......	“	24	65	4
base	237	“	24	65	4
bbro	237	“	24	65	4
base	237	“	24	65	4
gnetite and feldspar	238	“	24	65	4
bro	244	“	19	65	3
base with much magnetite	244	“	19	65	3
e 656b. without magnetite	244	“	19	65	3
glomeritic variety	245	“	19	65	3
gnetitic specimens	245	“	19	65	3
gnetitic slate	245	“	24	65	4
te from ledge	245	“	24	65	4
gnetite from band	245	“	21	65	4
gnetite from laminated portion	245	“	21	65	4
cimen of the slate	246	“	24	65	4

APPENDIX I.—Continued

Rock No.	BRIEF DESCRIPTION.	Report, 1887. Page	REGION.	Sec.	Town	Range.
665	Slate 1½ in. from gabbro	246	Gunflint lake	24	65	4
666	Magnetitic slate from contact	246	"	24	65	4
667	Gabbro in contact w. 666	246	"	24	65	4
668	Gabbro 5 or 6 feet higher than 667.	246	"	24	65	4
669	Gabbro 6 in. above 667	246	"	24	65	4
670	Gabbro 12 in. above 667	246	"	24	65	4
671	Gabbro 18 in. above 667	247	"	24	65	4
672	Magnetitic slate, a foot below contact	247	"	24	65	4
673	Magnetitic slate	247	"	25	65	4
674	Gabbro from cliff.	248	"	30	65	3
675	Magnetitic rock from slate ?)	249	"	28	65	3
676	Peculiar gabbro.	249	"	28	65	3
677	Collection of pebbles	249	"	27	65	3
678	Curiously banded flint.	249	"	27	65	3
679	Gabbro.	249	"	23	65	3
680	Gabbro.	249	"	23	65	3
681	Gabbro	249	"	19	65	2
682	Siliceous pebbles	250	"	16	65	2
683	Siliceous, magnetitic schist, black	261	"	18	65	2
684	Fine gabbro	261	" Canada.	18	65	2
685	Gabbrolitic magnetite.	261	"	18	65	2
686	Gabbro.	261	"	18	65	2
687	Chert	261	"	18	65	2
688	Granular rock from the slate.	261	"	13	65	3
689	Flint schist.	261	"	13	65	3
690	Gabbro.	261	"	13	65	3
691	Porphyritic noryte	300	Loon Lake	26	65	3
692	Gabbro.	300	"	26	65	3
693	Gabbrolitic rock	300	"	26	65	3
694	Gabbro.	300	"	26	65	3
695	Noryte—syenite-looking	300	"	26	65	3
696	Fine noryte.	300	"	27	65	3
697	Porphyritic noryte.	301	"	27	65	3
698	Gabbro w. much magnetite	301	"	27	65	3
699	Noryte	301	"	27	65	3
700	Noryte almost aphanitic	301	"	27	65	3
701	Gabbro	301	"	28	65	3
702	Fine noryte.	301	"	33	65	3
703	Gabbro weathered.	302	"	32	65	3
704	Gabbro w. large crystals	302	"	32	65	3
705	Fine noryte	302	"	32	65	3
706	Slate, prevailing condition	302	"	32	65	3
707	Slate, with scale-like areas	302	"	32	65	3
708	Gabbroloid slate	303	"	35	65	3
709	Prevailing character slate	303	"	35	65	3
710	Thin layer dark argillitic	303	"	35	65	3
711	Thin laminæ	303	"	35	65	3
712	From 8 feet above water	303	"	35	65	3
713	From 20 feet above water	303	"	35	65	3
714	Magnetitic slate, wavy bedding	303	"	36	65	3
715	Porphyry, coarse-textured.	304	"	26	65	3
716	Gneissoid syenite	240	Gunflint lake. Canada.	18	65	3
717	Magnetitic slate	240	"	17	65	3
718	Granular or oölitic magnitite	240	"	17	65	3
719	Siliceous slate, nearest syen	241	"	17	65	3

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1887.	REGION.		Sec.	Town.	Range.
720	Slate—varieties	242	Gunflint lake.	Canada.	18	65	3
721	Magnetite—varieties.	242	“		18	65	3
722	Magnetitic slate	242	“		20	65	3
723	Magnetitic slate, diabase looking	250	“		19	65	3
723b	Breccia of magnetitic slate	251	“		21	65	3
724	Fine noryte	253	“		22	65	3
725	Argillyte in vertical position	253	“		22	65	3
726	Vertical argillyte	254	“		15	65	3
727	Sericitic argillyte	254	“		22	65	3
728	Sericitic argillyte	256	“		22	65	3
729	Two structures in slate	253	“		22	65	3
730	Argillyte showing two struct	256	“		14	65	3
731	Argillyte with quartz grains.	256	“		14	65	3
732	Quartz-porphyritic slate	257	“		14	65	3
733	Porphyritic sericito-argillyte.	257	“		14	65	3
734	Porphyrelloid slate	257	“		14	65	3
735	White opaque quartz	257	“		14	65	3
736	Plain schist with two structures	257	“		14	65	3
737	Porphyrelloid rock	257	“		14	65	3
738	Porphyrelloid slate	258	“		14	65	3
739	Flinty contorted Animike and breccia	258	“		14	65	3
740	Pebbles from Rock 739	258	“		14	65	3
741	Biotite gneiss from fragments	259	“		14	65	3
742	Interleaved phyllyte	259	“		14	65	3
743	Graywacke	270	North lake		17	65	2
744	Syenite	270	“		16	65	2
745	Granular magnetitic rock.	271	“		16	65	2
746	Diabasic (?) rock	271	“		16	65	2
747	Gabbro	271	“		16	65	2
748	Gabbro and much magnetite	273	South lake		22	65	2
749	Magnetitic Animike	273	“		22	65	2
750	Gray Animike slate	274	Rat lake (Can)		19	65	1
751	Fine noryte	274	“		19	65	1
752	Gabbro	275	Rose lake		19	65	1
753	Gabbro	275	“		20	65	1
754	Gabbro	275	“		22	65	1
755	Animike argillyte.	276	“		22	65	1
756	Magnetitic Animike	276	“		24	65.	1
757	Iron rock	278	Rove lake		20	65	1E
758	Fine noryte	279	“		22	65	1E
759	Black rusty Anim slate.	279	“		22	65	1E
760	Fine dark, heavy noryte.	280	Mountain lake		21	65	2E
761	Coarse gabbro w. magnetite	281	“		13	65	2E
762	Three varieties of Animike.	282	Moose lake		20	65	3E
763	Coarse gabbro	282	“		22	65	3E
764	Animike with pure mag.	283	“		22	65	3E
765	Gabbro.	285	South Fowl lake		12	64	3E
766	Dolonnyte and quartz fr. gab	285	“		12	64	3E
767	Diabase from dike	285	“		12	64	3E
768	Olivinitic trap	288	Pigeon river		22	64	4E
769	Gabbro	288	“		22	64	4E
770	Olivinitic gabbro	289	“ (Can)		..	64	5E
771	Animike slate	291	Partridge falls		..	64	5E
772	Slate, prevailing character	291	Grand Portage (on		..	64	5E
773	Darker, thick bedded slate	291	“ Pig R)		..	64	5E

APPENDIX 1.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886	REGION.		Sec.	Town.	Range.
		Page					
774	Gabbro from dike	291	Partridge Falls		..	64	5E
775	Jointage of slate	291	“		..	64	5E
776	Peculiar gabbro	283	Moose lake.	Canada.	18	65	3E
777	Gabbro	273	South lake.		24	65	2
778	Gneiss	271	North lake.		10	65	2
779	Syenite gneiss	270	“		17	65	2
779*b*	Slate, in cont. w. gabbro	261	Gunflint lake.		13	65	3
780	Gabbro in cont. w. slate.	261	“		13	65	3
781	Gabbro 1 ft. above slate	261	“		13	65	3
782	Gabbro 4 ft. above slate.	261	“		13	65	3
783	Gabbro 10 ft. above slate	261	“		13	65	3
784	Flint from flint bed	261	“		13	65	3
785	Kewatin slates contorted	259	“		14	65	3
786	Sample of supposed eruptive	259	“		14	65	3
787	Condition admitted not eruptive	259	“		14	65	3
788	Condition also not eruptive	259	“		14	65	3
789	Other examples from same place as 725	253	“		22	65	3
790	Gabbro	305	Iron lake		36	65	3
791	Magnetite in gabbro	305	“		31	65	2
792	Gabbro with titaniferous iron	305	“		33	65	2
793	Animike rock fr. bowlder	306	“		33	65	2
794	Muscovado	305	“		31	65	2
795	Rusted Animike slate	305	“		31	65	2
796	Titaniferous gabbro	305	“		31	65	2
797	Muscovado	305	“		31	65	2
798	Pebbles in syenite bowlder	305	“		31	65	2
799	Hæmatitic rock	263	Gunflint Lake.	Canada.	18	65	2
800	Sericitic argillyte	263	“		18	65	2
801	Porphyritic porodyte	263	“		18	65	2
802	Semi-crystalline sericitic sch	263	“		18	65	2
803	Syenitic-looking Kewatin	263	“		18	65	2
804	Porphyritic porodyte	263	“		12	65	2
805	Uralitic syenite gneiss	264	“		12	65	2
806	Muscovite gneiss.	264	“		12	65	2
807	Transition to gneiss	265	“		12	65	2
808	Transition to gneiss	265	“		12	65	2
809	Transition to mica schist	265	“		12	65	2
810	Dike rock	265	“		12	65	2
811	Augitic? band in schist	265	“		12	65	2
812	Conglomeritic iron ore	263	“		18	65	2
813	Iron carbonate fr. Anim.	262	“		13	65	2
814	Black iron ore	262	“		18	65	2
815	Incipient muscovado	253	“		16	65	3
816	Iron carbonate beds	252	“		21	65	3
817	Dark Animike with iron	250	“		19	65	3
818	Brecciated Animike	251	“		21	65	3
819	Syenite gneiss	241	“		18	65	3
820	Hornblende schist pebble	241	“		18	65	3
821	Contact of last two	240	“		18	65	3
822	Diabase from dike (649)	233	“		13	65	4
823	Formative muscovado	238	“		24	65	4
824	Magnetite in contact w. 823	238	“		24	65	4
825	Oölitic quartzyte	238	“		24	65	4
826	Iron-bearing Animike	238	“		24	65	4
827	Slate w. scrobiculate surface	239	“		24	65	4

APPENDIX 1.—Continued.

BRIEF DESCRIPTION.	Report, 1887.	REGION.	Sec.	Town.	Range.
	Page.				
rty concretions (Batrachoides)	239	Gunflint lake	24	65	4
netite at surface	266	West of Gunflint lake	23	65	4
rtzose muscovado	267	"	23	65	4
ish, muscovado-like	267	"	23	65	4
natite	267	"	22	65	4
iss under hæmatite	267	"	22	65	4
ient soil between the two	267	"	22	65	4
rtz	215	Saganaga lake	14	66	5
ples of the formation	215	"	14	66	5
ples 8 rods north	215	"	14	66	5
ple from	215	"	14	66	5
athered surface	216	"	14	66	5
nded included mass	216	"	14	66	5
h reddish-weathering fels	216	"	14	66	5
ditic syenite	216	"	14	66	5
rtziferous granular felsyte	294	W. Seagull lake	8	65	5
i-chlorite argillyte	306	Frog Rock lake	17	65	5
llo-micaceous schist	307	"	17	65	5
hyrelloid graywacke	307	"	17	65	5
yte schist	308	"	17	65	5
yte schist	308	"	17	65	5
ase from dike	308	"	17	65	5
rite granulyte	308	"	17	65	5
nstone	308	"	17	65	5
ase	308	"	17	65	5
nstone w. much feldspar	308	"	17	65	5
nstone of fine texture	308	"	18	65	5
nstone coarser	308	"	18	65	5
itic felsyte schist	308	"	18	65	5
855*b* but harder	308	"	18	65	5
itic or chloritic felsyte	308	"	18	65	5
itic felsyte (schist ?)	308	"	18	65	5
ritic felsyte	312	"	18	65	5
hyrelloid chlorite-felsyte	312	"	18	65	5
nitic diabase	312	"	18	65	5
ase, same dike	312	"	18	65	5
itic schist	312	"	18	65	5
itic schist	312	"	18	65	5
itic chlorite felsyte	312	"	18	65	5
llo-felsitic schist	313	"	18	65	5
8 rods farther along shore	313	"	18	65	5
ritic sericitic schist	313	"	18	65	5
ure conglomerate	313	"	18	65	5
act chloritic argillyte	313	"	18	65	5
ite syenite pebble	313	"	18	65	5
itic schist	313	"	18	65	5
itic schist	313	"	18	65	5
act argillitic rock	313	"	18	65	5
874 but w. purplish tints	313	"	18	65	6
stone-like	313	"	18	65	5
stone passing to chlor. sch	314	"	18	65	5
stone 30 ft. fr. 877	314	"	18	65	5
stone	314	"	19	65	5
tic argillyte	314	"	19	65	5
sic conglomerate	314	"	18	65	5

APPENDIX I.—Continued.

Rock No.	BRIEF DESCRIPTION.	Report, 1886.	REGION.	Sec.	Town.	Range.
		Page				
882	Chloritic argillyte	314	Frog Rock lake	18	65	5
883	Sericitic schist	314	"	18	65	5
884	Chloritic sericitic schist	315	Town Line lake	18	65	5
885	Incipient porphyrel	315	"	18	65	5
886	Red jasper and hæmatite	315	"	18	65	5
887	Porphyritic conglomerate	315	"	13	65	6
888	Sericitic grit	315	"	13	65	6
889	Sericitic grit	315	"	13	65	6
890	Quartz grit	315	"	13	65	6
891	Sericitic schist	316	Ogishke Muncie lake	24	65	6
892	Brecciated dolomyte	316	"	24	65	6
893	Sericitic argillitic dolomyte	316	"	24	65	6
894	Silico-argillaceous slate	316	"	24	65	6
895	Felsitic grit	316	"	24	65	6
896	Gritty argillyte	317	"	24	65	6
897	Diabase conglomerate	317	"	24	65	6
898	Sericito argillaceous slate	317	"	24	65	6
899	Argillo-felsitic groundmass	317	"	24	65	6
900	Spheroidal concretions	317	"	24	65	6
901	Conglomerate	320	Crab lake	13	65	6
902	Porphyrel	320	"	13	65	6
903	Matrix showing bedding lines	320	"	13	65	6
904	Porphyritically quartzose congl	320	"	13	65	6
905	Argillyte	320	"	13	65	6
906	Fine gritty conglomerate	320	"	14	65	6
907	Graywacke	320	"	14	65	6
908	Graywacke	320	"	14	65	6
909	Graywacke or groundmass	320	"	14	65	6
910	Argillyte w. crys. of felds	320	"	14?	65	6
911	Compact argillyte	320	"	14?	65	6
912	Argillyte	320	"	14	65	6
913	Slaty argillyte	321	"	14	65	6
914	Conglomerate	321	"	14	65	6
915	Porphyrelloid conglomerate	321	"	14	65	6
916	Conglomerate (Ogishke)	321	Zeta lake	27	65	6
917	Groundmass of conglom	321	"	27	65	6
918	Banded argillyte	322	Epsilon lake	21	65	6
919	Banded argillyte	322	"	21	65	6
920	Kewatin slate	323	"	21	65	6
921	Animike slate	323	"	21	65	6
922	Schistosity and bedding	323	"	21	65	6
923	Sedimentary and schistic struc	324	"	20	65	6
924	Two structures conformable	324	"	20	65	6
925	Peroditic porphyrelloid slate	324	"	20	65	6
926	Noryte?	324	"	29	65	6
927	Noryte and porphyry in cont	325	"	29	65	6
928	Fragment of porphyry in noryte	325	"	29	65	6
929	Purple porphyry	325	"	29	65	6
930	Porphyritic greenstone	325	"	29	65	6
931	Kewatin, showing two structures	325	"	29	65	6
932	Amygdaloid porphyry	326	"	29	65	6
933	Varieties of purple porphyry	327	"	29	65	6
934	Kewatin argillyte	200	Knife lake	17	65	6
935	Finely porphyritic schist	200	"	17	65	6
936	Porphyrelloid rock	200	"	17	65	6

APPENDIX I.—Continued.

	BRIEF DESCRIPTION.	Report, 1887	REGION.	Sec.	Town.	Range.
		Page.				
	"Pulpit rock" noryte	200	Knife lake	16	65	6
	Gray felsitic slate	200	"	16	65	6
	Interlaminated argillyte	200	"	16	65	6
	Gray felsitic rock	200	"	16	65	6
	Banded argillyte	200	"	16	65	6
	Stuntz conglomerate	200	"	16	65	6
	Siliceous argillyte (Animike?)	200	"	16	65	6
	Stuntz conglomerate	201	"	15	65	6
	Diabase from dike	201	"	16	65	6
	Porphrel with fragments	202	"	16	65	6
	Argillyte (Animike?)	202	"	16	65	6
	Diabase from dike	202	"	16	65	6
	Slate in contact	202	"	16	65	6
	General character of slate	202	"	16	65	6
	Coarse material interbedded	202	"	16	65	6
	Fine, hard, diabase-looking	202	"	16	65	6
	Conglomeritic or brecciated	202	"	16	65	6
	Chlorite argillyte	202	"	17	65	6
	Porphyrellyte	205	"	12	65	7
	Slaty porphyrellyte	205	"	12	65	7
	Siliceous porphyrellyte	205	"	7	65	6
	Porphyrellyte	205	"	7	65	6
58	Conglomeritic porphyrel	205	"	7	65	6
59	Porphyrellyte	205	"	7	65	6
60	Gabbro with magnetite	206	"	7	65	6
61	Flinty porphyrellyte, contact	206	"	7	65	6
62	Magnetitic gabbro, contact	206	"	7	65	6
63	Gabbro	206	"	7	65	6
64	Gray semi-crystalline slate	208	" Can.	..	65	7
	Average gabbro	....	"	21	65	7
	Gabbro slate	209	"	21	65	7
	Olivinitic gabbro	209	"	21	65	7
	Greenstone	209	"	21	65	7
	Magnetitic gabbro	209	"	21	65	7
	Gabbro w. white feldspar	209	"	21	65	7
	Gabbro from N. bluff	209	"	21	65	7
	Gabbro w. much olivine	209	"	21	65	7
	Siliceous schist	210	"	..	..	..
	Gabbro	197	Canadian Lake	..	..	..
	Argillyte becoming mica schist	197	"	..	..	..
	Kawasachong argillyte	197	Pseudo messer L. } Canada.	..	..	..
	Porphyrel	197	"	..	..	..
	Micaceous green rock	.....	"	..	..	..
	Sericitic schist	327	Pipestone Falls	..	..	..
	Quartzitic argillyte	327	Garden lake	29	63	11
	Magnetitic siliceous slate	.....	"	29	63	11
	Banded quartzyte	327	"	29	63	11
	Mica sch. and magnetit. quartz	.....	"	29	63	11
	Mica and chloritic schist	328	"	29	63	11
	Hornblende sch. w. above	328	"	29	63	11
	Porphyrellitic schist	328	"	28	63	11
	Micaceous schist	328	"	28	63	11
88	Crumbling sericitic sch.	328	Vermilion mines near Tower			
89	Fine banded quartzyte	328	" "			
90	Graphite, near Tower	328	" "			

APPENDIX II.

Catalogue of lakes and portages along the national boundary.

Lake Superior. **1.** Grand Portage. 8 miles. XVI Report, p. 291.		
Pigeon River. **2.** Partridge Portage. .25 mile. XVI Report, p. 289.		
Pigeon River. **3.** English Portage. .33 mile. XVI Report, p. 289.		
Pigeon River. **4.** Portage. .6 mile. XVI Report, p. 288.		
Pigeon River. **5.** Long Portage. 1.5 miles. XVI Report, p. 287.		
South Fowl Lake. (No portage.)		*South Fowl Lake* (Treaty). *Lac de Coq* (Norwood).
North Fowl Lake. **6.** Portage. .75 mile. XVI Report, p. 282.		*North Fowl Lake* (Treaty). *Lac de Coq* (Norwood).
Moose Lake. **7.** Portage. .66 mile. XVI Report, p. 281.		
Pigeon River. **8.** Portage. .25 mile. XVI Report, p. 281.	Twin Lily Lakes.	*Lower Lily Lake* (Norwood).
Pigeon River. **9.** Portage. .25 mile. XVI Report, p. 281.		*Upper Lily Lake* (Norwood).
Mountain Lake. **10.** Divide Portage. .33 mile. XVI Report, p. 281.		*Hill Lake* (Norwood).
Rove Lake.—East part. (No portage.)		*Watab Lake* (Norwood).
Rove Lake.—West part. **11.** Portage. 1.5 miles. XVI Report, p. 276.		"*Several small ponds connected by narrows*" (Norwood).
Rose Lake. **12.** Rat Portage. .25 mile. XVI Report, p. 274.		*Mud Lake* (Norwood and N. H. Winchell).

Catalogue of lakes and portages along the national boundary.

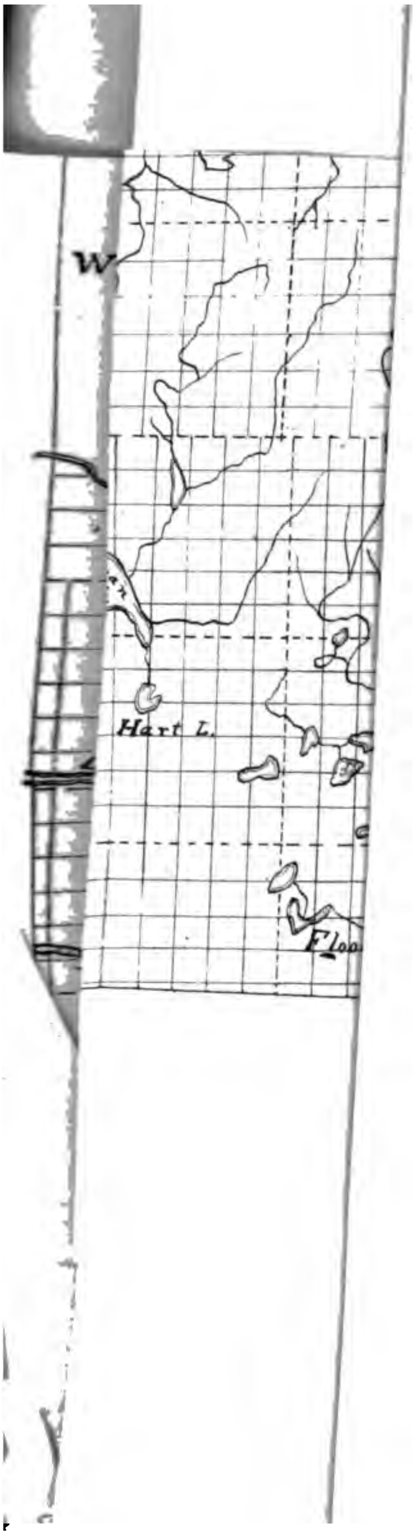
BOUNDARY RIVER.
36. (No. 6 rapids), Portage.
.35 mile. XV Report, p. 114.

BOUNDARY RIVER.
37. (No. 7 rapids), Portage.
.15 mile. XV Report, p. 114.

BOUNDARY RIVER.
38. (No. 8 rapids), Portage.

CROOKED LAKE.
39. (No. 9 rapids), Portage.
.15 mile. XV Report, p. 118.

IRON LAKE.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REPORT OF H. V. WINCHELL.

REPORT OF OBSERVATIONS MADE DURING THE SUMMER OF 1887.

By Horace V. Winchell.

Region traversed. During the months of July and August, an exploration covering a wide extent of territory was carried on. The writer, together with Mr. H. W. Fairbanks, of the University of Michigan, Mr. W. F. Trussell, of the University of Minnesota, and two Indian canoe-men, started from Tower, on Vermilion lake, with two birch-bark canoes and the necessary equipment for such a trip. The route, as here described, can be traced on the accompanying map.

The Little Fork river was reached by a four and a half mile portage from Vermilion lake. Eight days were spent in descending that stream to Rainy Lake river. No settlers were seen and not a traveller whether Indian or white man in that space of time.

We then ascended this large river, which forms the boundary line between the United States and Canada, as far as Fort Francis, which is situated at Chaudiere falls at the west end of Rainy lake. Our course for the next two weeks was along the south shore of Rainy lake through Black bay and into Namekan or Sturgeon lake by a portage of three-quarters of a mile; through Namekan lake to the east end, and south to Sand Points lake, through which Vermilion river runs before reaching Namekan and Rainy lakes, then north-west into Rainy lake again and back to Fort Francis along the south shore of the lake. It may be remarked that the water in all of the lakes and streams traversed during July and the first half of August was unusually high. It rained almost every day and sometimes continuously for a period of 24 hours while we were there. The Indians and white settlers along Rainy lake and Rainy Lake river said that it had been many years since they had known the water to be so high. This was unfortunate for geological investigation; as the outcrops were fewer and the exposure far less extensive than at times of low water.

From Fort Francis, Rainy Lake river was descended to the Big Fork river. Ascending this rapid stream by dint of hard paddling, poling and portaging, about 150 miles south and southwest, a portage of three-quarters of a mile took us across the divide between waters flowing north and south. This portage leads from Round lake into a small lake just south of it which is tributary to lake Winibigoshish and the Mississippi river. We next went down the Mississippi to Prairie river, making a stop at Pokegama lake to examine the hills at the south end, then up Prairie river and into the country which it drains, and finally down the Mississippi to Aikin on the Northern Pacific railroad. The month of September was spent in examining Elbow, Pelican, Net and Trout lakes. In this work the party consisted of W. F. Trussell, Frank Sopher a man who was acquainted with the region, and the writer. Some time was lost on account of high winds which rendered it impracticable to travel in a canoe.

Naturally the character of the country varies greatly in different regions. In the vicinity of Rainy, Namekan, Net, Pelican and Trout lakes it is very rocky, and all around the shores are numerous rock exposures; while west of these lakes the surface of the country consists of drift deposits and the underlying rock appears only at rapids or waterfalls in the streams and a few places in the midst of the forest. A large area of the land traversed by the Big Fork and Little Fork rivers is within the limits of the glacial lake Agassiz. This region is now covered with a fine growth of timber, both hard and soft wood, and is excellent farming land. It is slightly rolling or else flat and well watered by these large rivers and their numerous tributaries. Much of the pine that stood within a few years along these streams has been stolen and floated down to Lake of the Woods. This unlawful destruction of some of the finest of our Minnesota pine seems to be carried on every winter, as many of the logs freshly cut still lie around.

The following report is merely a transcription and rearrangement of the notes taken on the trip and follows very nearly the order of the journey. No attempt has been made to study the specimens collected. It will be a subject for future investigation to inquire into the lithological characters and relations of these rocks.

LITTLE FORK RIVER.

No exposures of solid rock are seen on the four and a half mile portage which starts from Vermilion lake in sec. 21, 63-18 and leads to the Little Fork. The portage crosses two large swamps and several small ones.

Some large irregular masses of biotite mica-schist give indication of the underlying rock. These chunks are cut by granite and syenite intrusions. Beds of drift gravel and sand are seen.

When the Little Fork is reached the character of the country is found to have undergone a marked change. There is more soil, clay and till, and consequently a larger and more luxuriant growth of forest-trees and shrubs.

The portage trail runs west for about a mile and then S. W. or S. S. W. The trees are poplar, pine, birch, elm, balm of Gilead, willow, spruce and tamarack. The country is low and not hilly. The Indian chief "Wakemaup" reports native copper in the rock at the falls twenty miles below here; he says he has cut it with his knife.

Descending the river in a general north-west direction the first rock is met with at about two miles. This is a low outcrop of massive dioryte. The outcrop is on the north side of the river and is seen for an extent of several rods, No. 75 (H).

There are occasional granite boulders in the river. The course of the stream is west for several miles.

About three miles below is Rapid No. 1.* The river falls about two feet in ten rods or less. Near the river the rock is a siliceous mica schist containing calcite and a varying amount of feldspar. On the ridge south of the river the schist becomes a fine biotite granite and contains veins and lumps of muscovite granite. It also effervesces with acid, and contains considerable pyrites. The exposure is not sufficient to determine the strike or dip. Nos. 76 (H), 76 A (H) 76 B (H). This schist seems to be uplifted by a moderately coarse, dark, tough massive rock somewhat like 75 (H) but coarser and containing magnetite (?). It has come up through the schist in places and forms a ridge running nearly north and south across the river. No. 77 (H).

About four miles below this rapid another short rapid is encountered. It is about 60 feet long and the river falls about a foot. This is Rapid No. 2. It is over mica schist or hydro-mica schist. Dip S, 70°, Strike and schistosity N. 80° E. The exposure rises only three or four feet above the water and extends but a few feet. It is coarsely fissile. A few large granite boulders lie about. White or bur oak, basswood, elm and ash trees appear among the other forest trees here. No. 78 (H).

About three-fourths of a mile below Rapid No. 2, Rice river joins the Little Fork; and a short distance below the confluence is a fall of about three and one-half feet and a rapid fall of a foot or two more. Rapid No. 3. This fall is over mica schist: some of it is very hard and siliceous, some soft, micaceous and fissile. There are beds of quartzyte and veins or beds of quartz in it. Dip. S. 60°—70°. Glacial striæ N. 20°E. strike east and west. The rock rises eight or ten feet above the water at the falls. The gorge is 40—50 feet wide and affords a good place for a dam.

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* The water was so high in this river in 1888 that an Indian said it was "all one rapid," under which circumstances the rapids here enumerated would be indistinguishable.

In some places the beds of schist and quartzyte are much mixed up and cross and cut each other in all directions. No. 79 (H).

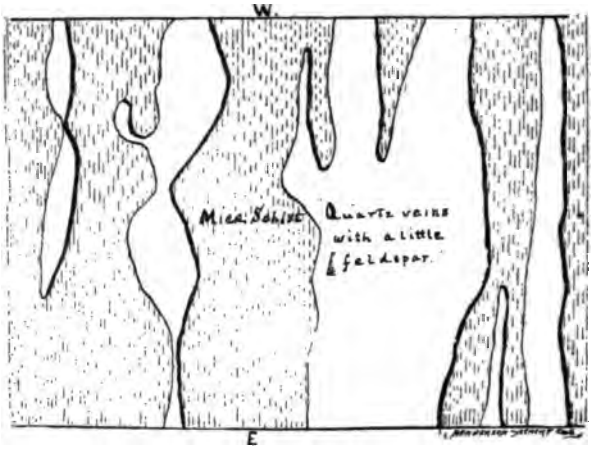

Fig. 1.—*Rapid No. 3, Little Fork river.*

About a quarter of a mile below the last is Rapid No. 4. It is a short rapid over boulders of granite.

A mile farther down is Rapid No. 5, about a quarter of a mile long. It produces a fall of six or eight feet in the river. There are a great many boulders of all sizes in the river and along the banks; no limestone boulders are to be seen as yet.

The rock is typical mica schist containing much fine biotite. There are inclusions of gneiss and syenite. The strike at the upper end of the rapid is S. 20° E. Dip is W. 80°. There are a few light-greenish felsitic pieces in the river that look as if they came from the rapids; but no rock like them could be found in place. They contain much pyrite which may be Wakemaup's "copper."

Two miles and a half or three miles below this is Rapid No. 6. It is about ten rods long and the fall is six or seven feet.

The rock is mica schist cut by a few granite intrusions. It is quite solid and compact but does not appear in any large outcrops. This rapid is just above the mouth of a river that comes in on the north side.

Between Rapids No. 5 and No. 6 are several places where there are boulders to be seen in the river and along the banks. This was not so above Rapid No. 5; perhaps because of the high stage of the water at the time.

The river continues in a western direction, sometimes running off for quite a while in a S. W. course.

Some of the schist at Rapid No. 6 contains so much feldspar and quartz that it might properly be called gneiss; and some has so little mica and feldspar as to constitute a grayish quartzyte.

Three miles farther down is a low outcrop of mica schist cut by gneiss. No. 80 (H) shows the contact. It is on the south side of the river.

About four miles below is a small outcrop in the bank on the north side of the river. It is a greenish schist much like the Vermilion lake gray wacke, containing a few mica scales and some pyrites. No. 81 (H).

About a mile below this are the "Big Falls" of the Little Fork. The fall is about 16 feet over a very much jointed, but quite fine-grained and compact green schist. It stands nearly vertical or with a high dip to the west. The strike is irregular but generally about N. 20° E. It is a rock that varies a great deal in different beds or layers. Some strata are very siliceous and hard with a tendency to basaltic structure; some very fissile and sericitic and some highly ferruginous with pyrites. Most all of it seems to contain considerable dolomite or calcite not only in seams but in the rock itself. There is also a greenish-black mineral or ore found in the seams. No. 82 A (H). Numerous quartz veins penetrate the rock, and part of it seems to contain much feldspar or felsyte. See No. 82 (H). This is Rapid No. 7.

No rock *in situ* is seen until Rapid No. 8 is reached, about 1½ miles below the falls. This is a low outcrop of the same rock as that at the falls. One who has come down the river from the region of mica schist to this fine-grained schist containing little or no mica cannot fail to have noticed the gradual change in this rock and the similarity of contiguous outcrops which go to prove it all of one formation.

About half a mile below this is Rapid No. 9, perhaps four rods long with a fall of about two feet.

Here there is an exposure of micaceous syenite gneiss which appears to be horizontally bedded. It is cut by veins of syenite and gneiss. There are large lumps of green material in the rock. No. 83 (H.)

About three miles below the last is Rapid No. 10; boulders being the only rock seen in that distance. This rapid is 12 or 15 rods long and descends 5 or 6 feet over a bed of boulders as far as could be seen. There are some rough pieces that seem to be broken from the underlying rock, and are of the gneiss and mica schist formation. The rock here has more quartz and feldspar than is the case generally farther east. Some of it is syenite containing a little mica. Sometimes, as for example on the portage around the south side of the "Big Falls," large masses of amphibolyte are seen that appear to be near home; but it was not seen in place. It is a heavy, massive, crystalline rock, apparently composed entirely of hornblende. It is noticeable that boulders and gravel in the stream are becoming of more frequent occurrence; and the country has a heavier covering of drift—gray clay with a few boulders. The land is low, but not swampy, and is good for farming. The river is large and still runs mainly west. Balm of Gilead and poplars constitute at least half the forest; ash and oak are numerous, and a few box-elders are seen.

About a mile and a half below Rapid No. 10 is a bank of gravel and boulders, among which are seen pieces of limestone. No. 84 (H.)

From here down the boulders are very numerous. About two miles and a half below is Rapid No. 11 over boulders of syenite containing a variable amount of hornblende. The rapid is short and the fall is not more than two feet.

A quarter of a mile farther is Rapid No. 12, only about a rod long, with a fall of about a foot. About three quarters of a mile below Rapid No. 12 is a bank of clay which contains boulders and is cut through by the river. The drift hills are higher here, and on the north side of the river this bank is 12 or 15 feet high. It contains limestone pebbles and clay concretions. No. 85 (H.)

Less than half a mile below this is Rapid No. 13 which descends about seven feet in a few rods. Here there is a large outcrop of very interesting rock. It is composed of coarse crystals of orthoclase running mostly all in the same general direction, mica, hornblende and a a little quartz, and contains garnets.

There is a long smooth-topped outcrop on the north side of the river, the general direction of which, as well as of the feldspar crystals in it is E 50° S. The only evidence of bedding is the direction of the majority of the crystals and also the direction of inclusions of fine mica schist which are numerous in the hard surface of the rock. These inclusions are softer than the rest of the rock and so the surface presents concavities where they lie.

Some of the crystals of orthoclase are nearly two inches long and are generally quite narrow. The rock has veins of granite running through it. The mica schist inclusions seem to stand with their bedding vertical; and the rock itself presents some appearance of it also. Boulders of this peculiar porphyritic rock had been seen in the river S. E. of this place. See No. 86 (H).

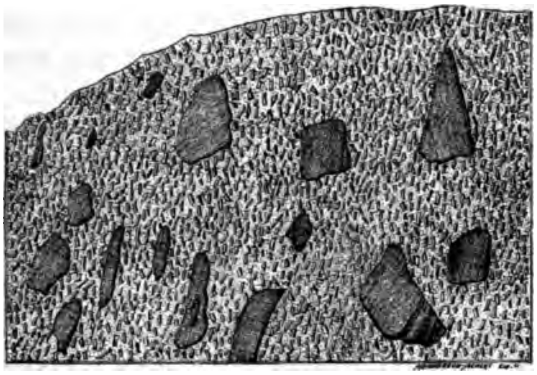

Fig. 2.—*Porphyritic Breccia. Rapid No.* 13, *Little Fork river.*

About a mile further down is Rapid No. 14 over boulders as far as could be seen. The principal rock is like 86 (H) but finer.

Half a mile below a large river enters on the south. It is called Sturgeon river by the Indians. Below this is a high ridge on the north side of the river.

About a mile further is Rapid No. 15, where the river cuts through rift hills 60 or 75 feet high. The rapid is 15 or 20 rods long, and the iver falls about three feet.

A mile below the last is Rapid No. 16, about 5 rods long over boulders. Small pieces of limestone are seen in most all of the drift ridges ow; and there is more sand mixed with the clay.

There is very little large timber growing here. Dead stumps of ees reaching up above the smaller growth of late years give evidence of what a fine forest existed here before fires ran over the untry and destroyed the vegetation. There are good-sized elm, h, birch, balm of Gilead and aspens along the river, and enormous uces and cedars occasionally; but the valuable timber is ruined.

A little more than a mile further down is Rapid No. 17, a small pid. A few limestone boulders here are a foot in diameter. See o. 87 (H).

About quarter of a mile further is Rapid No. 18, a short rapid over boulders and gravel. Just before reaching it is a clay bank on the west side of the river over 50 feet high.

Two miles further is an exposure of syenite gneiss just above Rapid No. 19. This gneiss has the same general character as that at Rapid No. 13, except that it contains much less mica, some of it none at all. There are garnets in it as in the other and also a few of the mica or hornblende schist inclusions. The rock at the south side of the outcrop is greenish schist containing mica and hornblende and but little feldspar.

This rapidly graduates into syenite poor in quartz, and further north this contains more feldspar than any other mineral. This syenite gneiss seems to be vertically bedded and to strike N. 10° E. No. 88 (H).

About two miles below the last is Rapid No. 20, where the river falls 8 feet in 100 yards or less. There are numerous large boulders here and a low exposure of fine green schist that looks like fine diabase. It is polished wonderfully smooth on the surface by glaciation. The direction of the striations is N. 10° E. Bedding is vertical; strike E. and W. It is full of joints, and a hand sample of regulation size can with difficulty be obtained. It is cut by a dyke of light-colored rock composed of quartz, feldspar, mica, hornblende, and garnets. It narrows down from six feet to one foot in 15 feet, going N. 20° E. It does not appear in abrupt contact with the green schist. Nos. 89 (H), 90 (H).

Forty rods farther is Rapid No 21, where there is a fall of two feet over boulders. Half or three-quarters of a mile below is Rapid No. 22. Just above this is an exposure on the south side of the river. It is a greenish mica schist that has a striking resemblance to that at Rapid No. 20; but contains much mica in fine scales. Bedding is vertical; strike N. 70° E; glacial marks N. 10° E.

Included in this mica schist are patches of a different kind of mica schist, also with vertical bedding and same strike. The schist contains quartz veins. Nos. 91 (H), 91 A (H).

Half a mile farther is Rapid No. 23, about four rods long with a fall of 4½ feet. The rock is mica schist similar to the last and containing quartz veins. Strike N. 80° E. Dip S. 70°. About a mile below a river enters on the east.

About two miles below the mouth of this river is Rapid No. 24 over boulders for a few rods. Two miles further on a good-sized stream comes in on the south, and 1½ miles farther a large creek enters on the east.

Very few boulders and no solid rock is seen for several miles along here. The river-banks are of clay. Just below the mouth of the river on the N. E. side is a clay bank 20 feet high. It is horizontally stratified and contains a few small pebbles. It is gray and somewhat sandy and appears to be of lacustrine or river deposit; but may be Cretaceous.

About half a mile farther is Rapid No. 25, about a quarter of a mile long over boulders. A short distance below, a creek enters from the S. W., and at the mouth of it is Rapid No. 26—a short rapid formed by boulders.

A little below this is a rapid 40 rods long or more over a bed of boulders. This is Rapid No. 27. Below this rapid for some distance the water is almost continually rapid and boulders are numerous. There is a sand and gravel bed here of which limestone pebbles constitute about one-half. Below this on the other side is a bank of boulders in which are some of limestone three or four feet in diameter. No. 92 (H).

Just around the bend a creek comes in on the east side, which has washed out a large bed of pebbles, most of which are limestone. The banks of this creek are lined and covered and fairly white with limestone. Lignite in a mass eight inches long, six inches wide and three inches thick, was found here. No. 93 (H). The banks of the creek are formed of very fine, sticky, horizontally stratified clay, which becomes hardened shale on drying. This clay is fine, soft, bluish-gray Cretaceous, in strata of from one to three inches thick. The banks of the creek for one-fourth mile back from the river are 20 to 25 feet high and formed of this shale. A total thickness of at least 40 feet can be seen at this place. A few cycloid fish scales and other fossiliferous remains were found in this shale.* Some gravel was seen in the clay in one or two places; also aggregations of fibrous yellow needles of aragonite. Nos. 94 (H), 95 (H), 96 (H), 97 (H), 98 (H) are from here.

It is remarkable to see the variety and number of boulders and pebbles that are in this creek bed. Limestone masses five feet thick occur; also pieces of a very peculiar conglomerate as well as of a fine, pink sandstone that looks like the Potsdam.

Half a mile farther down is a hill apparently composed of till which rises 50 or 60 feet above the river. A short distance below this is a bluff, 40 feet high, of shale. It is all very slippery and fine, with here and there a pebble. No fossils were found here. On the east side of the river below here the clay hills are 80 feet high.

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*Microscopic examination of this shale by Messrs. Woodward & Thomas reveals characteristic Cretaceous foraminifers.

Nothing worthy of note is seen for the next six miles; boulders are few and no solid rock is visible. At six miles a stream which has been used for driving logs comes in from the south, and forms a large bed of gravel and sand at its mouth. The banks of this stream are formed of the same muddy shale. The hills in this vicinity are 75 feet or even 100 feet high; and seem to be horizontally stratified to the very top. A few fragments of lignite were found here.

About two and one-half miles below this stream is Rapid No. 28, over some large boulders in the stream. There are some large flat masses of siliceous mica schist that do not appear to have traveled far; but the covering of drift and Cretaceous is too thick for the solid rock to be exposed.

About two and a half miles down the stream is seen the first meander corner. It is between sections 22 and 23, T. 65-24. A little below here a small stream enters from the S. E., and there is an old logging camp, "Seller's Camp."

About a mile below this camp, in the N. E. ¼ sec. 22, 65-24, is Oak Rapids (Rapid No. 29). At the top of these rapids is an outcrop of mica schist in the bed of the river. Strike is E. 10°S.; dip S. 20°. This schist may not be in its original position, although it appears to be. No. 100 (H). This rapid produces a fall of five or six feet in less than one-quarter mile. Considerable mica schist is exposed on the N. E. side. It is interbedded with gneiss. No. 101 (H). The schist near the foot of the rapids contains much quartz in veins, and many small garnets or grains of rose quartz. No. 102 (H).

At the west line of sec. 7, T. 65-24, is Rapid No. 30, over boulders for about five rods.

Just below the place where the river leaves T. 65-24 is Rapid No. 31, called "*Dead Man's Rapid.*" The rapid is over mica schist interbedded with gneiss, and the river falls ten or fifteen feet in about eighty rods. The schist dips south 72°. Strike is N. 80°E. It is very siliceous and also contains quartz veins. The beds of granite or gneiss are of all thicknesses up to three or four feet. Some of the schist weathers red on the surface, and some contains much hornblende. Part of the gneiss contains a bright green mineral near the surface. The outcrop is low and only rises a few feet above the water. No. 104 (H).

Around the point just below this rapid is a low exposure of massive syenite or dioryte. There are two sets of glacial striæ; one N. 20° E., the other E. 10° S. They are both well defined; but it could not be told which was of later date. This rock extends for two or three rods along the north bank. No. 105 (H).

A short distance below, on the other bank, is the ordinary mica schist cut by granite; so the dioryte is not very extensive, but may be in a dyke. It is very hard and massive; hardly a joint or crack being seen in the whole of it. Several very large granite boulders lie in the river near here, some 15 or 20 feet in diameter.

Half a mile below "Dead Man's rapid" is Rapid No. 32 over an ugly barrier of boulders.

A mile below this is Rapid No. 33, about 15 rods long over boulders. The river falls about 2 feet.

Half a mile farther is Rapid No. 34. Here there is an outcrop of mica schist, fine, biotitic and ferruginous, interbedded closely and strikingly with biotite-muscovite gneiss.

The gneiss and schist are in nearly vertical strata; dip S. 32°W. 75° and strike N. 58°E.

Less than one-quarter mile below is Rapid No. 35, a short rapid over boulders The banks along here are higher than have been seen for some time.

About 2 miles farther is a meander corner between sections 19 and 24, Twps. 66–24 and 66–25.

The hills below for several miles seem to be composed principally of till containing small boulders with which there is mixed considerable limestone.

Six miles from the last rapid is Rapid No. 36, having a fall of about a foot in a few rods. No rock but boulders was seen here.

About 1¾ miles farther down is a low outcrop of interbedded mica schist and granulyte, exposed for about 5 rods along the N. W. bank of the stream. The schist is vertically bedded; strike is N. 70° E. There are indications along the banks of the river of water in the river 12 feet higher than at the time these notes were taken, (July 5th.)

Two and a half miles farther, about in the N. E. ¼, T. 67–25, is an outcrop of doleryte less than a foot above the water. It is apparently a dyke running across the river N. and S. Glacial marks are long and deep, N. 42° E. No. 106 (H.)

Just below, around the point is an outcrop of mica schist interbedded with thin beds of gneiss. Strike is E. and W. Dip N. 65°. It is quite thin-bedded and is the characteristic rock of this whole region. In places it is hard to say which is schist and which is gneiss, or where one bed stops and the other commences, and again they are separated quite distinctly. It will be noticed that the dip has changed to the north. This schist causes Rapid No. 37, short and not steep. About a mile below a good sized stream enters on the south side.

Two miles further down is a low exposure of inter-bedded gneiss and mica schist. Glacial striæ are N. 40°E. Dip N. 50°. Strike E and W. The beds are very thin, fifteen alternating beds in a thickness of one foot being counted in one place.

About five miles farther down is Rapid No. 38 over boulders which probably rest on mica schist, as that is the material of which most of them are composed. There seem to be very few boulders in the till here. Small white pine and tamarack trees are beginning to be abundant. Box-elder is plentiful and soft maples are seen here and there.

Two miles farther down is a bank of Cretaceous shale on the west side of the river. It is sub-jacent to a mass of till and gravel. The latter contains many limestone pebbles. A few of these pebbles seem to be in the shale too. The bank consists of 20 feet of shale, and 10 feet of drift on top. The water from the surface filters down through the till and not being able to get through the shale forms springs of cold water coming out in the bank at many places. The shale is always wet and slippery and in thin beds. By a bed is meant a layer of clay with a line of fine sand or sandy clay at the bottom of it. The shale separates easiest at the line of sand.

Half a mile further is a low outcrop of mica schist and gneiss, and near it two immense granite boulders that look as if they were once one piece.

Three miles farther down the stream is a large, slightly elevated exposure in the middle of the river. It is nearly round and about 100 feet in diameter. It is composed of mica schist interbedded with and cut in all conceivable directions by coarse gneiss. This gneiss runs principally with the schist, but there are large and small veins that run straight across and twist through the schist in such a manner as to make a very rough and irregular surface where the gneiss stands above the weathered and washed out schist. The gneiss is very coarse; the crystals of feldspar and mica, both biotite and muscovite, being four and sometimes six inches on a side. The mica and quartz are often blood-red. The gneiss also contains garnets and tourmaline crystals four inches long, besides a green mineral that resembles beryl. Beds of rock composed mainly of biotite and augite occur in the schist.

The south side of this outcrop has a south dip; then comes a hard, wide bed of fine schist on the other side of which the dip is north at an indefinite angle. The general strike is about E. 20°S. Glacial striæ N. 22°E. Most of the feldspar is orthoclase, but there is also a light bluish-green feldspar in parts of it. Nos. 107 (H), 107A (H), 107B (H) and 108 (H) are samples from here. The large crystals of mica, as well as the biotite-augite (?) inclusions or beds, stand on edge.

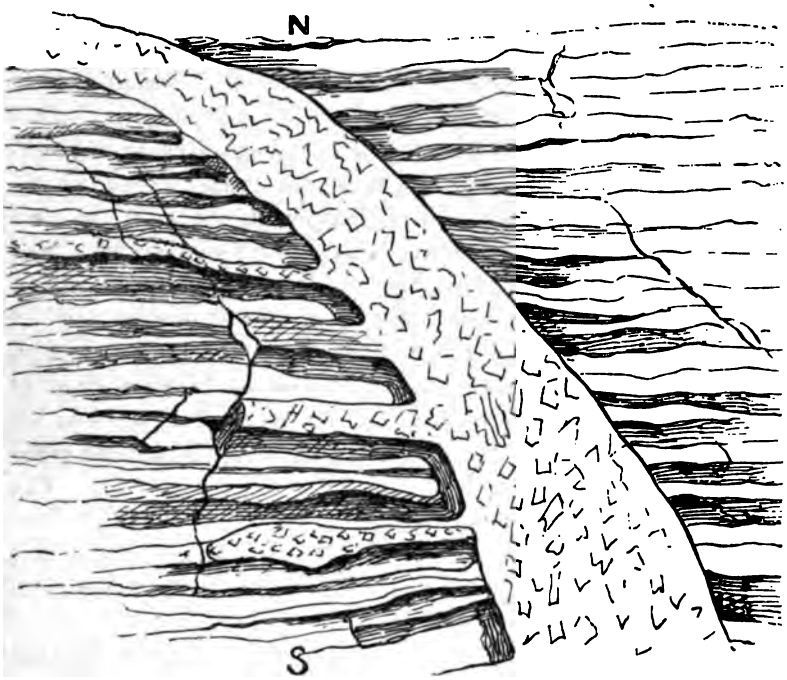

Fig. 3.—*Mica schist cut by granite, Little Fork river.*

The large intrusion of granite seen in the sketch to run across the beds seems to lie on the beds and not cut them much. It is very coarse. This is rapid No. 39 (Kabemabegetchiwak, "where the water goes round"). The river falls about three feet in the course of a few rods.

About a mile and a half below are three more outcrops of mica schist and gneiss. Strike is E. and W.; there is a high dip to the north.

About 3 miles farther on the west side of the river is a bank 18 or 20 feet high that has in the top of it about 10 feet of horizontally stratified clay of a light color and containing limestone, schist and other pebbles as large as 4 inches in diameter. No. 109 (H). This is probably in the bed of lake Agassiz.

Just below this is a low exposure of mica schist and gneiss in thin beds dipping north at a high angle and running east and west.

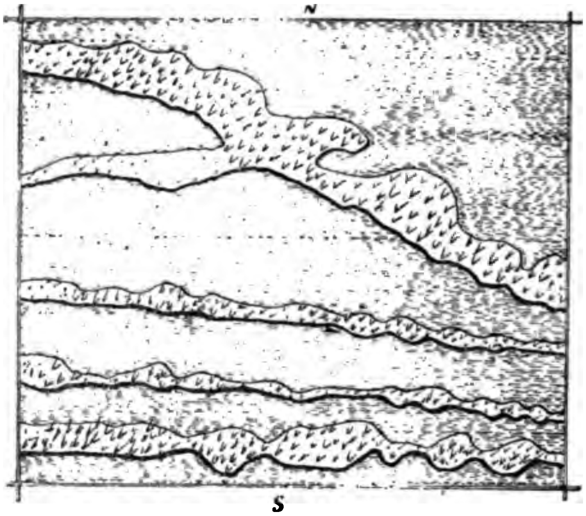

Fig. IV—*Mica Schist and Interbedded Gneiss, Little Fork river.*

About a mile below this is Rapid No. 40, over boulders for 20 rods. The river falls about 2½ feet.

Two miles below is a rapid fall of 6 feet over boulders. There is a clearing of 40 acres or more on a drift bluff 50 feet above the river. The Indians have come here each spring from time immemorial to catch sturgeon. Their name for it is *Onakaiamis* ("where the sturgeon run.") This rapid is No. 41 and is about 19 miles above Rainy Lake river.

About two miles below, Little Fork creek comes in on the east side. The drift hills and banks are 20 feet to 30 feet high here and are stratified at the top and perhaps all through.

About two and one-half miles further down is a layer of black gravel in the northeast bank of the river. It contains some magnetite. No. 110 (H).

RAINY LAKE RIVER.

Nothing particularly noteworthy is seen for the next fifteen miles, when Rainy Lake river is reached. The water in this river is much cooler and cleaner than that in the Little Fork, which is red and muddy. The banks are not more than 20 feet high and are more or less stratified. There seems to be an occasional exposure of Cretaceous shale. For eight and one-half miles up Rainy Lake river from the mouth of the Little Fork there is no rock to be seen in place. The banks are from five to fifty feet high and seem to be composed of till; but that cannot be positively ascertained as they are so rounded and covered with vegetation. There are numerous limestone boulders lying along the water's edge. There are settlers all along the British side and a few on the American. Oak trees are common and poplars are numerous.

About 3½ miles below Fort Francis is an exposure of mica schist in the middle of the river. Strike is N. 82° E.: dip N. 80°. Glaciation N. 32° E. This schist is quite fine and very fissile in places. It has a wavy, schistose structure running in the same general direction as the bedding. There are a few small beds of feldspathic material running through it. A couple of pieces lying on the surface which seem to belong here contain chlorite and pyrite and some other mineral. Nos 111 (H) and 112 (H).

About a mile and a half below Fort Francis is a long exposure of green hydro-micaceous schist on the British side. Strike is N. 40° E. Dip at a high angle to the north or vertical. There are a few scales of unaltered mica in the schist and some dolomite in the veins and seams. No 113 (H). There are some beds that are very siliceous with fine grains of quartz that crumble and separate with a slight blow of a hammer. They resemble the quartz beds in the jasper schists north of Tower. No. 114 (H).

There is a bed of green schist or rock possessing a schistose structure that runs so as to slightly cut the bedding of the schist. It is about two feet wide and continues for several rods. It seems to be a little softer that the other schist and has about the same composition. No. 115 (H). It looks as though it may have been of a dyke-like nature and had its schistosity formed at a later period by lateral pressure. The character of its constituents has also been changed.

A little further up the river on the same side is an exposure that rises 15 feet above the water. Here the schist contains twisted beds of quartz stained with iron which have a marked resemblance to those in the Vermilion lake rocks. No. 116 (H). See figs. 5 and 6.

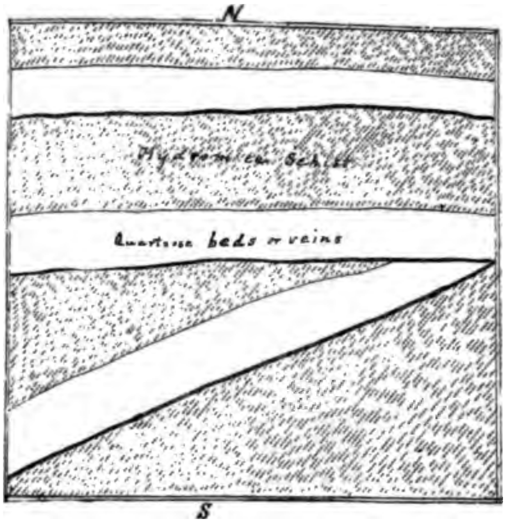

Fig. 5.—*Rainy Lake river.*

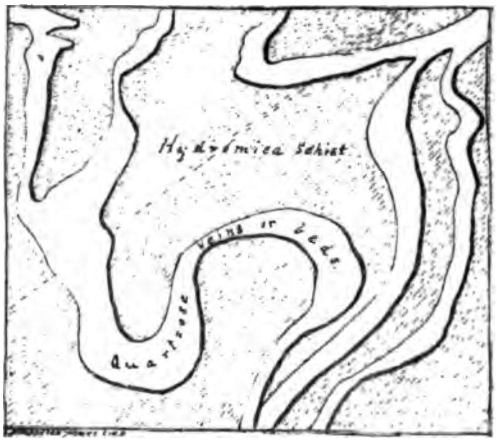

Fig. 6.—*Rainy Lake river.*

On the south end of a small island in the middle of the river is a small, massive outcrop of porphyritic granite. It is exceedingly porous but tough. Crystals of feldspar less than an inch in length stand out all over the surface The rock also contains mica and hornblende or chlorite and a very little quartz. Going east a short distance nodules of hardened mica schist are seen enclosed in the other rock. Soon the rphyry* begins to have more and more of the green minerals in it; d finally it becomes fine, hard mica schist. Along the strike there a gradual transition from porphyry to schist; but in one or two ots they have an abrupt contact. Some of the nodules are porphy- c. Nos. 117 (H), 117 A (H), 117 B (H), 117 C (H), 117 D (H), 117 H) and 117 F (H) are from here.

The island just east of this one is composed of the same porphyritic k with beds (for it certainly is bedded in places) of a fine crystal- e greenstone. It is astonishing how quickly an apparently massive eous rock can become gneissoid and then schistose. There seems e no choice between hornblende and mica; of two specimens taken of the solid rock less than three feet from each other, one is mi- eous and the other hornblendic. Nos. 118 (H), 118 A (H), 119 (H) 120 (H).

he same porphyritic rock forms the American shore for a long way he river. It contains masses of mica schist in it, entirely sur- nded by the porphyry and merging into it. There are straight, l-defined bands of greenstone in it that seem to be dykes. The one met with was hard trap at the west end, and schistose rock feet farther east. Nos. 121 (H) and 121 A (H).

urther along is a dike six feet wide cutting right through the por- ry. Its direction is N. 72° E. Dip S. 62°. On the surface, por- s of this dyke look much like the porphyry, but of finer composi- . The edges, however, are well marked and the contact abrupt. . 122 (H) and 122A (H).

ometimes the green mineral in the porphyry is like chlorite and feldspar is pink instead of cream-colored or white as in most of No. 123 (H).

ust beyond the dyke last mentioned the porphyry contains masses greenstone several feet in diameter, and winds and twists al nd them. The most of this greenstone is similar to the dyke No. 122 (H), but on one side of one of the inclusions is regular schist which grades into the "greenstone." No. 124 (H).

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s rock has a semi-crystalline groundmass but is called porphyry here for convenience.

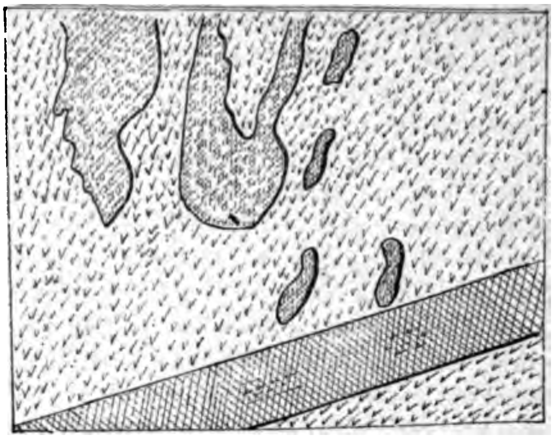


Fig. 7.—*Dyke cutting porphyritic breccia, Rainy Lake river.*

This porphyritic gneiss continues up to Fort Francis, where it forms a waterfall twenty-five feet high. At this place the rock has been blasted out to a depth of thirty feet to make a lock. The entire rock is shown by this means to contain the rounded lumps of dark schist of all sizes up to several feet in diameter, to a depth of at least thirty feet. No. 125 (H). There seems to have been some mighty metamorphosing agent at work, which uplifted and changed a belt of mica schist into porphyritic gneiss. The general direction of this ridge or belt of altered schist is from N. W. to S. E., i. e., if the similar rock at the west end of Pelican lake be, as seems probable, a continuation of this same rock.

Half a mile above the falls, on the American side, is a low outcrop of syenite, porphyritic with red and green feldspar. The red is very decidedly red, but seems to be orthoclase. No. 126 (H).

About a mile further is an outcrop of mica schist in vertical strata, with a strike N. 48°E. It appears the same as usual, and has nothing to show that it is so near an extensive belt of metamorphism. The shores of the sluggish stream conform to the strike of this schist all the way to Rainy lake. Some of it is exceedingly soft and fine, and crumbles easily.

The second rapid below the lake is over mica schist which contains many small quarts veins. Strike is N. 54° E ; dip north at a high angle.

The rock on the Canadian side at the Agency is hard and jointed and bears evidence of considerable baking. No. 127 (H).

RAINY LAKE.

Mica schist, much jointed and with fine veins of quartz and gneiss, is seen in a low outcrop on the point in N. W. ¼ sec. 29, 71-23. On the east side of this point the schist seems to be of two kinds; one siliceous and granular crystalline, the other soft and fine, both mixed and twisted up together. No. 128 (H) shows the two kinds in contact. In the small bay around this point are many large boulders of gneiss, schist and greenstone.

The point in the N. E. ¼ sec. 29, 71-23, is a low exposure of mica schist. The general strike is N. 70° E. There are beds of a semi-crystalline, grayish-green rock in the schist and running in the same general direction, but sometimes cutting the beds. This rock weathers faster than the schist and the surface is white from the feldspar in it. It contains also pyrite, hornblende and a soft green mineral, probably chlorite. There are three of these beds on this point. No. 129 (H). The dip of the schists is north at a high angle. There are small veins of quartz and granite in the schist.

The point in the N. W. ¼ sec. 28, 71-23, is composed of mica schist. Dip. is N. 72°. Strike N. 70° E. The strata of schist vary in different parts. One side, presumably that which was originally at the bottom, is coarser and darker than the other. When therefore the coarse side of one stratum comes in contact with fine upper side of another stratum they do not look like the same rock. The finer side of the beds is the north side at this locality. No limestone boulders have been seen since reaching the lake. The schist at this place contains veins of dark red quartz. No. 130 (H).

Around the point the rock becomes coarser and contains grains of siliceo-feldspathic material. Glaciation N. 32° E. No. 131 (H).

In the center of sec. 28, 71-23, the rock is a very fine, hard, green schist. The mica which it contains is exceedingly fine. No. 132 (H). The surface of this schist is sometimes covered with long slender crystals of hornblende. No. 133 (H).

Along the shore in the N. E. ¼, sec. 28, 71–23, the schist contains many very ferruginous quartz veins. Some of the beds of schist are quite decayed and jointed on account of the iron in them.

In this locality there is a trap dyke nearly 3 feet wide running E. 60° S. across and through the beds of schist. It does not seem to incline any from vertical. The surface of the rock is covered with small, green crystals that look like epidote, but seem too soft. Nos. 134 (H) and 134A (H.)

A little farther east is much more of the ferruginous schist in large, soft beds. No. 135 (H.) The general dip here is N. 45°. Small, crooked beds of granulyte occur in the schist and appear to become more numerous toward the east. The strike has changed to E 10° S. Boulders of gneiss and mica schist interstratified with each other are becoming very numerous. The schist is occasionally quite hard and contains some hornblende. Dip is N. 40°. No. 136 (H.)

On one of the numerous sand beaches is a deposit of very green sand. It looks like the mineral seen on the surface of the dyke rock. No. 134 A (H.)

There is another small dyke a little coarser than the last a little farther east. Its direction is N. 60° E. It is about 2 feet wide and weathers light.green on the surface. No. 138 (H).

The beds of schist begin to be very different from each other and contain much quartz and feldspar besides an undetermined green mineral. No. 139 (H). A little further along, still in sec. 28, 71-23, the schist becomes very thin, bedded and fine-grained and lies in long parallel beds. Strike is N. 72° E, No. 140 (H). Some beds in the schist here are quite hydro-micaceous. No. 141 (H).

The south side of the small island in N. E. ¼ sec. 28, 71-23, is formed of mica schist. Lying against it upon the north is white granite or gneiss. The contact is abrupt and distinct; but the granite has sent out branches that cut the schist, and has also enclosed a few pieces of schist in it. The granite is cut by intrusions of granulyte and granite containing but a little mica. The only evidence of gneissoid structure is the arrangement of the minerals in parallel lines. These have about the same general direction as the schist, viz. N. 60° E. The masses of schist that are enclosed in the gneiss are unaltered and seem to have retained their strike and dip. Nos. 142 (H) and 143 A (H). The larger island at this same place is composed almost entirely of granite. In one place only a few short beds of schist were seen. The middle of the island rises 25 feet above the water There are small masses of schist enclosed in the granite in variou places. No. 144 (H).

In the N. E. ¼ sec. 27, 71-23, the schist lies against the gneiss al along the coast. They are mixed and cut and twisted up together i a remarkable fashion. Long feelers of the gneiss or granite stretc off through and across the beds of schist, and from them branch ou smaller winding, twisting veins in all directions. The general line o contact seems to be in the direction of the bedding of the schist.

In the N. E. ¼, of N. E. ¼, sec. 27, 71-23, is a dyke which is 35 pace from one side of it to where it goes under the water and disappears. On the west side it is a fine diabase. This becomes coarser and coarser toward the middle of the dyke. The rock on the west side of it is fine, hard mica schist. The line of the west side of the dyke runs E. 60° S. Glacial marks are N. 40° E. Nos. 145 (H), 145A (H), 145B (H), 145C (H), 145D (H), 145E (H) and 145F (H), show the change in the rock in crossing the dyke.

The coarsest side of this dyke which is naturally supposed to be the middle, is at the water's edge, and it can not be determined where the rest of it has gone or whether there is any more. If the coarsest part is the middle, the dyke is 210 feet across.

Jack pine trees are numerous in this region. Not one was seen on the Little Fork.

The dyke mentioned above continues to form the shores of the islands and main-land for a long distance going E. 50° S. Its edges are irregular and sometimes penetrate a long distance into the schist; but the line of contact is always distinct. This dyke probably contains magnetite; as the compass is disturbed by its proximity. Some of it contains epidote. No. 146 (H).

The long point in sec. 26, 71-23, is composed of micaceous and hydromicaceous schist containing quartz in veins.

A round polished knob of the dyke rock sticks up in the middle of the bay south of the east end of the point mentioned above. This is very finely marked by glaciation. The augite crystals are arranged in long rows which run at about right angles to the glacial marks. There is so much disturbance of the needle here that direction can not be determined by the compass.

On the south side of the bay in sec. 26, 71-23, is what appears to be the continuation of the dyke. It contains beds of coarse, dark schist running N. 70° E. No. 148 (H). In some places this very trap rock has a bedded structure and almost becomes schist with a strike similar to that of all the schists in this region, and apparently in vertical beds. Nos. 149 (H) and 149 A (H).

In the S. W. ¼, sec. 25, same township, this diabase has all graduated into a rock that is very plainly gneiss; and going a little farther south across the strike it is still further changed into thin-bedded gneiss and finally into mica schist with the ordinary strike and dip.

In the S. E ¼ of S. W. ¼, sec 25, 71-23, is a high bare knob of mica schist. It contains a quartz vein three or four feet thick running across the beds. There are also beds containing an unknown, heavy, black mineral. No. 150 (H).

In the S. E. ¼ of S. E. ¼, sec. 25, 71-23, the shore is composed of dioryte (?). This becomes finer toward the south until it graduates into doleryte or trap. Then comes a fine-grained, thin-bedded, green schist dipping north at a high angle and with a strike N. 80° E. Its contact with the doleryte is abrupt and irregular. The hills rise 75 feet above the lake and are almost bare. The schist is quite siliceous and finely micaceous. No. 151 (H). This dyke seems to be the continuation of the large one mentioned above, but is narrower here.

In the S. W. ¼, sec. 30, 71–22, the mica schist is conglomeritic, containing innumerable flattened pebbles and boulders all changed into rock very similar to the schist. No. 152 (H). There is also a greenish mica schist here that is very smooth and even in its composition and seems to be in thicker beds than the rest. No. 153 (H).

A little farther east in sec. 30, 71–22, the schist assumes the appearance of a decided conglomerate, containing pebbles of granite, quartzyte and schist as large as eight inches in diameter. On a smooth surface they show very plainly. No. 154 (H). Some of the beds of schist are light-colored and are more like gneiss. No. 155 (H). Some of the schist also contains hydromica in place of mica.

In the S. E. ¼, sec. 30, 71–22, the schist contains less and less mica until it becomes almost a fine granulyte or quartzyte. Nos. 156 (H), 156 A (H) and 156 B (H). Near the east side of sec. 29, 71–22, the glaciation is N. 60° E.

There is a great deal of hydromica schist on an island in the N. E. ¼ sec. 32, 71-22. For a mile or two west of here the bluffs 40 feet high are composed of light-colored siliceous schist. At this place the schist is very fine and hydromicaceous, and contains beds of the light-colored schist. Dip is N. 45°. No. 157 (H).

The point in the north half of sec. 33, 71-22, is composed of mica schist that rises 50 feet above the lake. It stands in vertical strata.

The point in S. E. ¼ of N. W. ¼. sec. 33, 71-22, contains two or three quartz veins, one three feet thick, running with the bedding N. 48° E. The schist stands on edge. It contains beds of hard gneissoid rock.

In the S. W. ¼ of S. W. ¼. sec 34, 71-22, the strike of the schist is east and west. Some of it is beautifully fine and soft; and some is folded and wrinkled in parallel beds. The dip is north at a high angle.

Along the west side of sec. 3, 70–22, the schist is in thin, straight beds dipping north at a lower angle than usual. There are also beds f gneiss in it and numerous quartz veins. The general strike is bout E; dip is N. 50°.

In the N. E. ¼ of N. W. ¼, sec. 10, 70-22, is an outcrop of gneiss owing for several rods along the shore. It contains irregular atches of hard, coarse, hornblendic mica schist. The gneiss has an regular contact with the schist and encloses some of it. The schist n the east side of the gneiss dips N. 40°—50°. No. 158 (H). Strike is . 40° S. In the east half of sec. 10, the strike veers around until it is . 70° S. and even E. 80° S. This schist is thick-bedded and dips N. . 40°.

The round point in the S. ½ sec. 10, 70-22, is composed of a gneissoid ica schist very much jointed. Strike is E. 40° S.

Mica schist is exposed in S. W. ¼ sec. 13, 70-22. It is quite feld-athic, soft and crumbling. There are very few exposures in this bay hich is called Black Bay by the white settlers of the region, and azushkatabiwi, or *Rat Root* lake by the Indians. Most of its shores e marshy and the bay itself is full of rushes and rice.

Near the east side of sec. 13, 70-22, the schistose gneiss strikes east d dips N. 48°. A good portage of about a mile connects Black Bay ith Kabetogamak (*the lake that lies along the side*). On the portage . sec. 19,70-21, ridges of gneissoid mica schist are crossed which end N. 70° to N. 80° E. No. 160 (H).

In the N. W. ¼ of S. E. ¼ of the same section mica schist occurs terbedded with coarse gneiss. Strike N. 70° E. Dip N. 58°.

In the S. E. ¼ of S. W. ¼ sec. 27, 70-18 the beds of schist have a dip . 80°; strike is N. 84° E. The point near the center of S. W. ¼ sec. 7, 70-18 is made of perfectly straight parallel beds of schist standing early vertical. There are also a few beds of gneiss. Some of the eds have a high dip to the south. No. 176 (H) from this place contains green muscovite.

Biotite, muscovite schist is found in N. W. ¼ of N. E ¼, sec. 28, 70-18, dipping S. 76°. Strike is E. There are narrow beds of gneiss, granite intrusions and quartz veins in the schist here.

In the S. E. ¼ of S. W. ¼ sec. 21, 70-18, the schist dips S. 73°. It contains a few thin beds of gneiss. Glaciation is N. 40° E. Strike is N. 88° E. Boulders are numerous here. No. 178 (H). A little way north is a granite intrusion that cuts the beds of schist considerably. It is four feet thick and contains coarse orthoclase and muscovite like the regular beds of gneiss. A few rods further north is another intrusion of granite having a general direction N. 50° E. It is quite coarse and is porphyritic in places. There is a gneissoid structure running directly across the intrusion, the minerals and the weathering both showing it plainly. No. 179 (H).

The schists north of this for some distance are not so regular, but are more thickly bedded. They weather into irregular lumps and not into thin sheets as usual. There are occasional narrow, winding intrusions of granite about six inches thick, that seem to be filled with muscovite in plates half an inch to an inch in length.

In the N. W. ¼ of S. W. ¼, sec. 21, 70-18, are numerous intrusions, all having a general trend of N. 50° E.—N. 60° E. They generally have a dip similar to the schist. They frequently contain large orthoclase crystals which have quartz in them, thus forming a graphic granite. No. 180A (H). Some of the schist contains red beds in which all of the ingredients have a reddish tinge.

Occasionally the intrusions are quite gneissic. No. 182 (H) is a sample from one of them that winds around and cuts across the beds of schist, and is finally pinched down from thirty inches to two inches in thickness. Some of these intrusions are garnetiferous. No. 183 (H).

There is a small rock island in the S. E. ¼ of S. W. ¼, sec. 21, 70-18, that seems to form part of a very large granite intrusion. It runs across to the north end of the larger island east of it, where it is about 70 feet wide. It trends N. 55° E. It is composed mainly of graphic granite, which contains coarse muscovite and garnets and becomes gneissoid in places. No. 184 (H). There are also large and small masses and bunches of silvery or light-greenish quartz and mica in fine grains and scales, arranged in fibrous rays. It occurs in considerable quantities in this locality. No. 184A (H). Perhaps the term "greisen" might be applied to this rock.

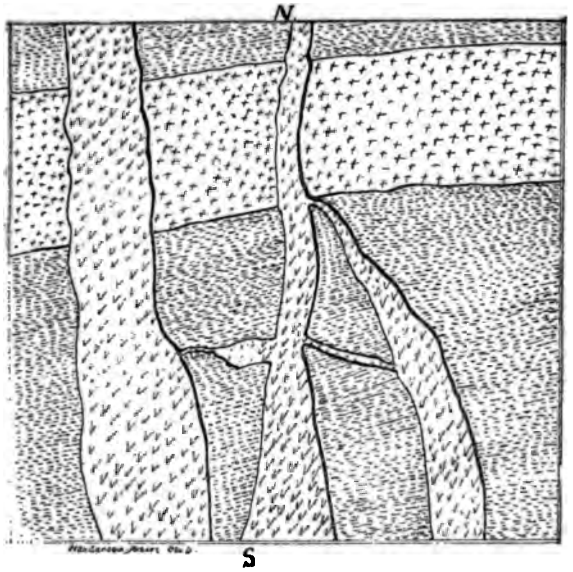
Beds of gneiss are seen in S. E. ¼ sec. 20, 70-18, having a very gneissoid appearance and striking N. 60° E. They also contain the peculiar masses of quartz and muscovite. No. 186 (H).

Just east of the last the schist is remarkably straight and smooth. Strike is N. 83° E. Dip S. 80°.

On the point in the S. E. corner of S. W. ¼ of S. W. ¼, sec. 20, 70-18 is a curious example of the way in which the granite intrusions cut the schist and twist about in it.

The beds of gneiss are quite coarse and contain considerable quartz and muscovite. The orthoclase is yellow. The schist aboutas usual. Strike N. 84° E.

In the N. W. ¼ S. E. ¼, sec. 19, 70-18, are more large and small beds of gneiss. Some of them conform with the strike of the schist here.



Gneiss and mica schist cut by granite, L. Kabetogamak,
S. E. ¼ sec. 31, 70-21.

)eds of gneiss are quite coarse and contain considerable quartz
scovite. The orthoclase is yellow. The schist about as usual.
N. 84° E.

e N. W. ¼, S. E. ¼, sec. 19, 70-18, are more large and small beds
ss. Some of them conform with the strike of the schist here.
ittle singular that all the intrusions observed for several miles
here have a general trend N. 60° E. and the schist N. 80° E.
e schist strikes N. 74° E. and dips S. 80°. The beds or intru-
' gneiss still contain considerable quantities of the above men-
·adiated quartz and muscovite.

is place is a bed of gneiss that cuts across the schist for some
, then comes into conformity with it and all at once splits up
n beds an inch or two thick and becomes lost in the schist. It
ır two feet wide at the start and maintained its thickness until
ed. These intrusions or beds of gneiss—for either name seems
; times,—frequently enclose long strips of schist which some-
ıaintain their usual strike and sometimes take that of the sur-
ıg and enclosing rock. Glaciation is N. 44° E Some of the
ı in the schist are half an inch deep and an inch wide.

times the gneiss laps over and lies upon the edges of a good
ıeds of schist as if it had been squeezed up and out, and had
over. Most of it is porphyritic.

e S. W. ¼ of S. W. ¼ sec. 19, 70-18, the schist occurs in beds which average about two feet thick and strike N. 74° E, with a dip S. 82°. It is uniform and regular. There are large intrusions of granite running through it, N. 40° E. Part of the west side of a bluff has fallen into the lake and left a fresh break showing graphic granite containing muscovite Each individual crystal of orthoclase seems to contain quartz grains running in the same direction through it according to some cleavage or other natural tendency in the feldspar. Two crystals of orthoclase are never seen side by side with the quartz running the same way in both; but in each individual however large the quartz "characters" are all parallel or at right angles to each other. No. 187 (H).

In the S. E ¼ sec. 24, 70-19, the schist rises in bluffs twenty-five feet above the lake. There is also much gneiss here. Some of it contains large quantities of immense biotite scales. The strike of the schist here is N. 74° E, dip is S. 74°. The schist here is regular and uninterrupted in perfectly even, thick beds for one hundred feet at a time. Glacial striations N. 46° E.

The point at the south line of S. E. ¼, sec. 23, 70-19, is composed of gneiss containing much of the quartz and mica masses and graphic granite. No. 188 (H) is from a mass of the former two feet long.

The N. E. ¼ of N. E. ¼, sec. 27, 70-19, is composed of mica schist, with a strike N. 76°E and dip S. 80°, and large beds of gneiss. Glaciation is north 50°E. A little east of here the straight walls of mica schist and, in one place of gneiss, rise up thirty feet from the water's edge, covered with moss and lichens. The trees are mostly a thick growth of small spruce and Jack pine.

The point in the S. W. ¼ of sec. 23, 70-19, is composed of mica schist and gneiss. The latter is full of radiated masses of quartz and mica in fine, glistening scales. It seems to have been pushed over the beds of schist in a plastic condition and to have a sort of horizontal gneissoid structure. It is quite coarse, and is porphyritic in places. The strike of the schist is N. 84°E.

Fine-grained patches are often seen in these intrusions or beds of gneiss. The fine parts are often porphyritic, with perfect orthoclase crystals six to ten inches across. Frequently there are beds of pebbles and accumulations of boulders on a point or in some recess where there is a large bed of gneiss. These pebbles and boulders are principally of the same rock as that directly beneath and around them; and seem to have been formed right there by the action of frost and waves of the lake. No. 190 (H).

The rock in N. W. ¼ sec. 20, 70-19, is principally mica schist. Strike is N. 70° E. Dip S. 80°, in thick beds. No. 191 (H). There are hard nodules in it, as there are most everywhere, that stand out n knobs and sheets and all sorts of odd shapes on weathered surfaces. It also seems to be cut by hard veins of matter which cross themselves and make a net-work of little ridges on the weathered surfaces. They do not seem to have any influence on the cleavage of the rock.

In the S. E. ¼ sec. 19, 70-19, there is a bed of chloritic (?) mica schist in the other schist. It is four or five feet thick and contains much black mica in scales. It is cut off by an intrusion of granite which crosses the east end of it; and hidden by the lake on the west. Its general trend is N. 80° E. No. 192 (H). There are hard veins running through it that seem to have been gneissoid, but now contain hornblende or chlorite and but little mica.

The point of the island in S. E. ¼ of N. E. ¼, sec. 24, 70-20, is composed of garnetiferous gneiss, porphyritic with very large orthoclase, and containing quantities of the masses of mica scales and quartz grains. All of the large orthoclase crystals are pegmatitic.

The mica schist in the S. W. ¼ of N. E. ¼, sec. 23, 70-20, strikes E. 0°S; dips S. W. 78°; and has glacial marks N. 46°E. It is in hick beds, and the mica is biotite. There are beds of porphyritic gneiss here as everywhere in this region, only this has more of the radiated accumulations of mica and quartz. There is often a decidedly gneissic structure in these beds, but they are generally without it.

The schist in the N. E. ¼ of S. E. ¼, sec. 16, 70-20, is quite thick-bedded in nearly vertical strata. Strike, N. 80°E. Glaciation, N. 15°E. There are but few granite intrusions in this region, and the shores are lower and frequently covered with vegetation down to the water's edge. The lake at this time was unusually high. Streams of water were pouring into it on all sides from places where usually there is no stream at all. There was a cascade over each bluff, and a roaring little torrent down each ravine.

In the N. E. ¼ of N. W. ¼, sec. 15, 70-20, the schist lies flat, in thin laminæ or plates. For several rods along the water's edge the flat schist lies piled up six or eight feet above the water, like slabs in a wood pile. No. 193 (H). This continues around the point for some distance, becoming thicker and coarser. From here it goes on to the S. E. ¼ of S. W. ¼, sec. 10 in a rather confused and disturbed way, now dipping north, now south and now lying flat. This seems to be the middle of an anticlinal,—and, in fact, the dip soon becomes permanently to the north. Beds of gneiss are still seen in the schist, but here they too are broken and discontinuous. Around the point farther, beds of schist two and three feet thick dip N. 40° to N. 60°.

Strike is N. 80°E. Some of the schist here is very rich in garnets. Nos. 194 (H) and 194A (H).

On the N. E. ¼ of N. E. ¼ sec. 16, and S. E. ¼ of S. E ¼ sec. 9, 70-20, the schist is flat again. It rises twenty feet above the lake. There is a bed of gneiss which has come up through with a dip N. 60°; and there are other small granite intrusions that lie flat and cut through the gneiss for several rods.

In the S. W. ¼ of S. E. ¼ sec. 9, 70-20 is a bed of gneiss three feet thick that lies on the top of flat beds of schist all the way around the point.

In the S. W. ¼, of S. W. ¼ sec. 9, 70-20 the schist is still distorted and contains garnets and considerable biotite. The granite intrusions run more irregularly than usual through the schist in this supposed middle of an anticlinal. The shores are all much lower here than farther east; and are inclined to be marshy. Veins of white quartz tw or three feet thick are common in this locality.

The schist in the S. ½ of sec. 7, 70-20 has a north dip varying fro 60° to 80°. The strike is E. It is a little harder here than usual an contains quartz veins and garnets. The bedding is wavy. No. 197 (H)

In the N. E. ¼ of N. E. ¼ of sec. 12, 70-21, is the first large bed o gneiss that occurs along here for several miles. It embraces severa masses of schist. It is porphyritic and quite gneissic and contain much peculiar green mica, especially near the contact with the schist. It also contains a few garnets and has quartz veins penetrating it. The schist near it has a strike N. 80°, and a low dip to the north. Nos. 198 (H) and 198A (H).

In the N. E. ¼ of N. W. ¼, sec. 12, 70-21 the schist rises about thirty-five feet above the lake. It strikes N. 70° E. Long, grayish-blue crystals of cyanite are found in some quartzose veins near the water's edge. Some of the blades of this mineral are six inches long. No. 199 (H).

The schist in the S. E. ¼ of S. W. ¼, sec. 1, 70-21, contains man quartzose beds and one or two veins of quartz. There are numerou garnets in these beds. No. 200 (H.)

The walls of schist on the north side of the bay, in sec. 1, 70-2 have glacial scratches along the smooth, perpendicular sides in a directions, but the majority are nearly horizontal. Sometimes th mark curves around a point or corner of the rock and continues o the other side as if the ice conformed to the outlines of the rock surface and walls.

The mica schist in the N. E. ¼, sec. 6, 70-20, is in thick beds tha strike N. 70°E and dip N. 35° to 38°. Long, low reefs of this roc run out into the lake, and the shores are low. Few or no granite c gneiss beds are to be seen in this region. The schist is exceedingly uniform in the appearance and composition of its strata.

The south side of the point in sections 31, 32 and 33, 71-20, is composed of mica schist in beds of different degrees of hardness and amount of mica, but which have a general sameness of appearance. At the end of the point is some porphyritic gneiss in beds running about N. 50°E. The general strike of the schist is N. 70°E; the dip N. 35°. In places there is a jointage structure that crosses the bedding and divides the schist into angular plates and prismatic forms. The south side of this point presents the long beds broken off in a succession of rows that resemble walls of masonry slanting a little to the north. The schist on the north side of the point in S. E. ¼ of N. W. ¼, sec. 33, 71-20, strikes N. 80°E., and dips N. 52°. No. 201 (H). Small quartz veins occur in it, running with the strike. The mica in some of the schist is in spots, and gives the rock a mottled appearance.

No. 203 (H) is hard mica schist from S. W. ¼, sec. 29, 71-20. It strikes N. 76°E. and dips N. 60°, more or less. The schist here has some appearance of being conglomeritic. It is in very thick masses that do not show any banded structure, as some of the schist does. A little further west, in the N. W. ¼ of S. W. ¼, sec. 29, 71-20, there are beds of schist that are hydro-micaceous, and have a wavy structure running with the bedding. No. 204 (H).

Some of the beds in the mica schist in the S. W. ¼ of S. E. ¼, sec. 26, 71-21, are quite siliceous, with finely granular quartz. No. 205 (H). The beds here are vertical, or have a high dip to the north, and the strike is about N. 80° E., but is becoming irregular and broken. No beds of gneiss are seen in the schist here. Quartz veins are numerous.

On the point in the S. E. ¼ of N. W. ¼, sec. 35, 71-21, the mica schist changes gradually into a rock composed principally of augite (?). It has no apparent bedding and is quite massive for a short distance. The continuation of it is lost in the water. This change takes place in going across the strike from north to south, the strike being about E. Some of this massive rock contains glassy quartz in veins. The schist here is finely banded and dips N. 72°. Nos. 206 (H) to 206 F (H) are from this place.

The point in the S. W. ¼ of N. E. ¼, sec. 34, 71-21, is composed of evenly-bedded mica schist. Strike N. 86° E. dip N. 74°. Glaciation N. 64° E. There are no beds of gneiss here; but quartz veins eight inches to two feet thick, running with the bedding are frequent. These veins are sometimes connected by cross-veins.

The schist in the S. W. ¼ of the N. W. ¼, sec. 34, 71-21, contains both mica and hydromica. Strike is N. 84° E. Many of the strata have reddish veins of quartz running with the strike and scattered all through the bed. The schist is also garnetiferous. No. 207 (H).

Some beds in the schist on the point in the S. W. ¼ of N. W. ¼, sec. 33, 71-21, are lighter colored and more siliceous than usual. Strike is N. 80° E.; dip is about vertical. No. 208 (H). The schist in this immediate vicinity is very thin bedded; and where the sheets have fallen over into the lake overlapping each other they look like shingles on a roof. These siliceous beds became felsitic in the N. W. ¼ of N. E. ¼, sec. 32, 71-21. Strike is N. 74° E., dip S. 60°. No. 209 (H).

No. 210 (H) is a sample of mica schist from the S. E. ¼ of N. W. ¼, sec. 32, 71-21. The beds here are about vertical; strike N. 74° E. Quartz veins are numerous, and boulders, of which we have seen very few if any in the last three townships, are becoming more plentiful.

In the N. E. ¼ of N. W. ¼, sec. 31, 71-21, the schist is cut slightly by a greenstone dyke six inches thick. The direction of the schist is about E. 10° S. and that of the dyke is E., although it curves. No. 211 (H). This is the first greenstone dyke seen since coming into this lake from Kabetogamak.

In the N. E. ¼ of N. W. ¼, sec. 31, 71-21, the schist contains several beds of a light color that seem to be composed of small rounded quartz grains, biotite scales and larger scales of some opaque mineral, probably feldspar. The strike here is N. 74° E. The schist is also hydromicaceous. These light colored beds vary from an inch to two feet in thickness. Nos. 212 (H), 212A (H) and 212B (H). In the N. E. ¼ sec. 36, 71-22, there are more of these siliceous beds in the schist; some of them are felsitic and some sericitic.

The schist in the S. E. ¼ of S. E. ¼, sec. 24, 71-22, contains both mica and hydromica. It becomes more fissile and wavy in its structure toward the west, and in the S. W. ¼ of S. W. ¼, sec. 26, 71-22, it is very schistose. Here there are many quartz veins in it, and little streaks of lighter-colored feldspathic beds. The dip at this place is north; while a short distance east of here it is distinctly to the south. Strike is about N. 74° E. There are numerous thin felsitic beds in the schist here.

A light-colored, siliceous schist is found on an island in the S. E. ¼, sec. 28, 71-22. It is quite hard, and does not weather easily. Strike is N. 84° E. Glaciation, N. 52° E.

The south side of the island, in the N. E. ¼ of S. W. ¼, sec. 28, 71–22, is composed of siliceous schist that strikes east, and stands in vertical beds.

The east end of the island, in the S. E. ¼, sec. 19, 71–22, is composed of hydromica schist, varying to graywacke, and even to a harder, semi-crystalline rock, containing chalcedonic quartz, opaque feldspar and pyrites. The general strike is about east; dip is north to vertical. Some of the schist is very fissile, and some has almost lost its schistose appearance. Some of it seems to be chloritic; and all of it contains considerable carbonate of lime in the seams, and to a certain extent in the rock itself. No. 216 (H).

In the N. E. ¼ of S. E. ¼, sec. 19, 71–22, on the south side of the large island, the schist is diabasic, and assumes a jointed structure; but the schistose structure is still everywhere apparent. Strike is N. 74° E.; dip north at a high angle. No. 217 (H).

No. 218 (H) is from the south side of the island, about a quarter of a mile west of last. It is hydromica schist, that dips north, and forms the highest part of the coast in this place. It is quite schistose, and contains many small veins of quartz. Strike is about N. 76° E.

Mica schist is again found in the S. W. ¼ of S. E. ¼, sec. 24, 71–23. It contains also a little hydrated mica. Strike is about N. 70° E.; dip at a high angle to the north. Light-colored, feldspathic mica schist, somewhat stained with iron rust, is found in the S. E ¼ of S. W. ¼ of the same section.

In the S. W. ¼ of S. W. ¼, sec 24, 71-23, is a ridge of doleryte that becomes very coarse near the top and middle of the ridge. It has an irregular, abrupt contact with the mica schist on the north. The general direction of the contact is N. 80°E. It rises thirty-five feet above the lake, and is very solid and massive. Glaciation is N. 60°E. No. 220 (H).

On the point of the S. E. ¼ of S. E. ¼, sec. 23, 71-23, this doleryte rises in hills at least eighty feet above the water. It is an exceedingly tough rock, and causes the needle to point south. It seems to be cut by veins or "dykelets" of fine trap in places. There is a coarse jointage structure running about north. This structure is also seen in the hardened mica schist which lies at the east side of the dyke. Nos. 221 (H) and 222 (H).

No. 223 (H) is from the S. W. ¼ of S. W. ¼, sec. 23, 71-22. It is hard, greenish schist, which strikes N. 75°E. It appears to be semi-crystallized. It lies between mica schist on the south and hydromica schist on the north.

KABETOGAMAK

On the portage in sec. 19, 70-21, ridges of gneissoid mica schist are crossed which trend N. 70°E. to N. 80°E. In the N. W. ¼ of S. E. ¼, sec. 30, 70-21, is mica schist mixed with coarse gneiss. Strike is N. 70°E; dip N. 58°.

The small island in the S. W. ¼ of S. E. ¼, sec. 30, 70-21, is composed of interbedded mica schist and gneiss. The gneiss is quite coarse, is muscovitic and lies in thick beds. It contains also a little biotite. No. 161 (H).

The mica schist in this region is often cut by beds or veins of black mica schist that weathers sooner than the rest of the schist. The gneiss contains pyrite and some small crystals of a black mineral like tourmaline. It also contains irregular patches of the schist.

The point in the N. E. ¼, sec. 31, 70-21, is composed of interbedded gneiss and mica schist. The gneiss is often very coarse, containing mica crystals four inches long, and orthoclase six inches across. No. 165 (H). Both schist and gneiss are cut by intrusions of granite running in all directions. The general strike is N. 70°E; dip N. 45° to 50°.

The S. E. ¼ of sec. 31, 70-21, contains a point nearly bare of vegetation, composed of rounded knobs of gneiss and mica schist cut by granite intrusions. Some of the orthoclase crystals in the gneiss measure ten inches in length. The strike of the gneiss and schist is N. 80°E. The following diagram shows how the granite cuts the mica schist.

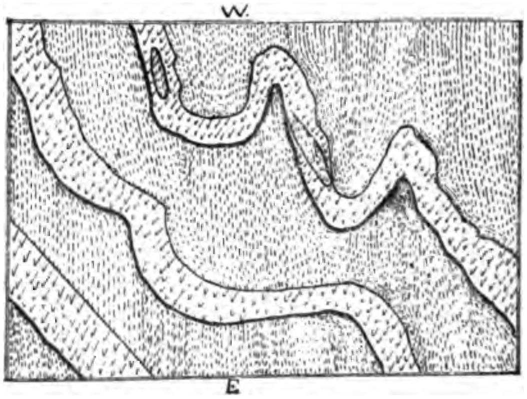


Fig. 9. *Mica schist cut by granite. Rainy lake, S. W. ¼, sec.* 20, 70-18.

In the N. E. ¼ of N. W. ¼, se[illegible] 6, 69-21, is a bold bluff of gneiss, containing some mica schist. It is pegmatitic also. No. 162 (H). The gneiss is very coarse, and contains large crystals of muscovite. It is a little peculiar that the mica schist, which is found in patches all through this gneiss, contains chiefly biotite mica; while the gneiss contains muscovite. There is some muscovite, however, in the schist, and a little biotite in the gneiss. No 163 (H). The graphic granite here seems to be crystals of orthoclase, two feet or more in length, containing quartz The surface of each mass of feldspar has one common cleavage, and reflects the sun as if it were one flat surface.

Mica schist and gneiss are seen in the N. E. ¼ of N. W. ¼, sec. 8, 69-21. Strike is N. 80° E. There seems to be a tendency in all of this gneiss for the different constituents to separate from each other, and to collect as much as possible by themselves.

Gneiss and schist are found in the N. E. ¼ of the N. W. ¼, sec. 17, 69-21. Strike is N. 80° E. Dip is north, at a high angle. When the beds of gneiss are thin the crystals are smaller than in the thick beds.

Where the line between secs. 20 and 21, 69-21, crosses the shore-line there is a round hill of gneiss and mica schist that rises at least fifty feet above the lake. The feldspar weathers white on the surface, and makes the rock quite dazzling in the sun. There is less mica in the gneiss here; but the beds and included masses of mica schist are quite common. The strike is N. 70° to N. 80° E. Dip still to the north. No boulders are seen at the west end of this lake.

Gneiss and mica schist, with an east and west strike and a dip N. 16° to 30°, occurs in the N. E. ¼ of N. W. ¼, sec. 27, 69-21. A few boulders lie along the shore here; but no drift covers the rock hills. Mountain ash trees are first noticed at this place.

In the S. W. ¼, sec. 25, 69-21, the gneiss and schist still have a low north dip, 15°-30°. The gneiss is sometimes porphyritic, and contains very black biotite. No. 164 (H).

In the N. W. ¼ of N. W. ¼, sec. 30, 69-20, gneiss and mica schist occur in interbedded, thin, wavy or folded strata. Strike is E. 50° S. to E. 80° S., and with a low dip of less than 45° to the east. The character of the rock remains unchanged for a long distance east of here. It is always gneiss and mica schist in more or less distorted beds. Much of the gneiss is porphyritic, and contains large scales of both biotite and muscovite. The quartz is often chalcedonic. Most all of the large orthoclase crystals contain quartz, being thus pegmatitic. The beds become too much bent and twisted for any general strike or dip to be noted. The country is more wooded and hilly, and the rock comes down close to the water in perpendicular bluffs, over twenty-five feet high.

There is such a mixture in the rocks that beds of any considerable length are not to be seen. Masses round, square, oblong, irregular, thin, thick and in fact all shapes and sizes of mica schist are seen in the gneiss where the gneiss predominates, and of gneiss in the schist where the schist is the main rock.

Sometimes the strata lie in wavy, horizontal beds, and sometimes they stand nearly vertical. The gneiss is frequently porphyritic, and occasionally rock that approximates mica schist rather than gneiss is porphyritic with feldspar crystals two or three inches long. The trees are Norway pine, white pine, Bank's pine, spruce, balsam-fir, birch, aspen, great-toothed poplar, mountain ash, white cedar, willow, ash and elm.

In the N. E. ¼, sec. 30, 69-19, there are beds of schist and gneiss that seem to be more regular. and have the usual strike and high dip to the north. The country through here is much wilder than that farther west. There is considerable good pine on the shores of the lake. The rock hills generally rise to a hight of fifty feet or more above the lake.

Mr. Trussell examined the north shore of Kabetogamak, through Twp. 69-20, up to Namekan, in Twp. 69-19. The formation is all the same—gneiss and mica schist in irregular beds. One specimen from the north side containing much biotite is No. 166 (H).

NAMEKAN LAKE.

The west end of Namekan or Sturgeon lake is very beautiful. There are numerous points and islands, all heavily wooded down to the water's edge. The hills rise higher, too, in this region, and the bluffs have a bolder aspect. The rock is the usual gneiss and mica schist, the latter generally quite soft and crumbling, so that the gneiss is the rock that is most seen in all exposures.

In the S. E. ¼ of S. W ¼. sec. 26, 69-19, the gneiss and schist rises seventy-five feet in perpendicular bluffs, from which many large pieces have fallen down into the lake and left overhanging crags that have quite a picturesque appearance. There are pine and spruce trees growing in every available crack and crevice of the solid rock.

In the S. W. ¼ of S W. ¼, sec. 28, 69-19, the rock is more gneissoid than usual, and contains but little schist. It rises twenty-five feet to fifty feet above the lake on the islands and points in this locality. It is cut and re-cut by granite intrusions, but no trap or dioryte dykes are seen on this lake. Nos. 167 (H) and 168 (H). The strike in N. W. ¼ of S. E. ¼, sec. 30, 69-18, is E. 70° S.; dip E. 45° to 60°.

In the S. E. ¼ of S. W. ¼, sec. 28, 69-18, the strike is more regular and has returned to its general direction, N. 70°—N. 80°E., with a high dip N. Many mica schist beds occur in the gneiss, and serve to show the strike and dip better than the gneiss does.

The gneiss in the S. W. ¼, sec. 26, 69-18, is fine and red, and contains very few beds of mica schist. There is a coarse, schistose structure running E. 60°S No. 169 (H).

In the N. W. ¼, sec. 31, 69-17, the rock is almost pure mica schist. There are a few beds of gneiss, but the rock is largely schist, in thin, straight beds. Some of the strata are nearly horizontal, and some dip 60° or more to the east. The flat beds are folded and bent considerably.

In the S. W. ¼, sec. 28, 69-17, the gneiss begins to appear again in thick beds, but the schist still predominates. The strike of the gneiss is about east and west, with a dip N. 40°.

On the west side of the island, in the S. E. ¼ of N. W. ¼, sec. 29, 69-17, is a bed or dyke of dioryte about twenty feet thick. No. 170 (H).

The channel of the stream which flows from Sand Points lake into Namekan lake is one of the most picturesque spots seen in this region. The stream is deep and narrow, and runs between rugged bluffs of mica schist. The hills are covered with pine and the rocks with a luxuriant growth of lichens. The rocky walls are almost continuous enough to deserve the name of "dalles." They are all of mica schist having a general strike about east and west, and dipping about N. 45°. There are occasional beds of gneiss and veins of quartz.

The rock on the island in the S. E. ¼ of N. W. ¼, sec. 21, 69-18, is gneiss and mica schist. The gneiss is fine-grained, and contains irregular masses of the schist. It is only slightly foliated. No. 171 (H).

The entrance to Rainy lake is quite intricate, and is hard to find, as well as hard to keep when found. The plats do not follow the regular noe route for the boundary, but take the north channel between mekan and Rainy lakes, where a canoe seldom goes, because of the er portage.

re are two falls between these lakes. The southern one is a f about nine feet, over mica schist. There is a good portage of wo hundred paces on the south side.

The rock in this region is mica schist, with beds of gneiss. It is quite regular in bedding, strike and dip. Strike is N. 80° E. Dip about N. 80°. The beds of gneiss are quite generally in conformity with the schist; but sometimes cut it a little. No. 172 (H).

The north fall is about the same hight in one *chute* as the south fall. It is over fine, hard, brittle mica schist. No. 173 (H.) The schist is very evenly bedded, and stands nearly on edge. Strike is N. 86° E. Dip, N. 84°. Glaciation, N. 30° E. The gneiss beds are very uniform, and are conformable with the schist. It is generally coarse, and contains garnets. Some of it, however, is quite fine, and shows the gneissic structure well. The mica in the schist is mostly biotite; that in the gneiss is muscovite. Some of the schist is hydromicaceous. No. 175 (H).

BIG FORK RIVER.

This river should really be called Bowstring river, inasmuch as the Indian name *Pisachabani* signifies that, and it comes from Bowstring lake.

No rock is seen on Rainy Lake river between the mouths of the Little Fork and Big Fork rivers, which are only six miles apart. Stratified, sandy clay is seen in the banks ten and even twenty feet above the river. A few limestone boulders are to be seen.

The banks of the Big Fork for the first three miles up the stream are not more than five feet high. No rock in place nor boulders are seen. Then the banks become higher and in places are twelve feet to fifteen feet high, composed of stratified sand and clay. The water is dark and the river has a smaller volume than the Little Fork.

The stratified clay banks have in them beds containing pebbles of gneiss and other rocks; they also contain very fine clayey layers. On top is generally a few inches of loose sand or soil. About seven miles up the river the clay banks are seen to contain quantities of fresh-water shells. No. 224 (H) is clay in which these shells are imbedded. It was taken out of a bank about fifteen feet above the water in the river and five feet from the top of the bank. The whole bank is made of the stratified clay; and as far as could be seen contained fragments of shells, as well as boulders and pebbles.

There is a very swift current in this river. Boulders begin to be numerous at about two miles up the river, and pieces of Cretaceous shale are seen on the bank. Small fragments of limestone too, are frequently seen. The trees noticed in the first ten miles are as follows: Plenty of large hardwood timber of all the varieties mentioned, swood, soft maple, elm, black ash, white ash, white oak, aspen, ite birch, balm of Gilead, box elder, three varieties of willow, iron-od, cottonwood, spruce, white cedar, Norway pine, Jack pine, moun-n maple, dogwood, cherry, alder and June berry. The banks ome higher in the next ten miles, and groves of fine Norway pine seen at intervals. The water was so high that no short rapids re noticed; it was all one long rapid.

he neighboring country is quite flat and a good share of it is mpy. There are chances for many fine farms along this stream. e river bed seems to be paved with boulders, and there is much vel in the banks, which are all composed of stratified drift. They covered with vegetation, part of which was overflowed by the high ter.

bout 27 miles above the mouth of the river the first rapid is en-ntered. At this place a large mass of gneiss and mica schist trudes from the water. It may not be in place. Boulders are very nerous The banks are lower, being seldom more than ten or lve feet high. They are all, so far as could be seen, composed of tified sandy clay containing pebbles and boulders. There are ny fragments of limestone and Cretaceous shale. No large masses limestone were seen; but there may be plenty of them which would exposed in the bed of the river at times of low water. Much fine e has been stolen along this river, and still a great deal remains.

Passing two or three quite rapid places in the river, the first exposure rock was found at a rapid which flows between banks 30 feet high the east side of the river, and 40 feet high on the west. This is out 33 miles up the river. The rock is trap; and no other rock can found on either side of it. It is seen only on the east bank of the ver where there is a large exposure of it about 12 feet across and 6 et above the river. No. 226 (H).

The banks contain gravel and sandy clay and appear to be stratified. he many springs which issue from the banks near the bottom indicate at the Cretaceous underlies them. Pieces of this shale are seen in e banks up to the top.

Several tall trees were ascended for the purpose of viewing the sur-unding country. It was seen to be all of one general level.

Opimabonowin river enters on the west side, about thirty-seven iles up the river. There is a rapid over boulders up this river a hort distance. Above the mouth of this river, on the Big Fork, apids are of frequent occurrence for four miles, when the "Big Falls" re reached. This is not one perpendicular fall, but consists of rapids and one or two steep *chutes*. It was so hemmed in and covered by a "jam" of logs that it could not be measured, but it was estimated that the fall is not more than twenty feet in one-eighth mile.

The rock is gneiss and mica schist, which is cut at the head of the falls by a trap dyke at least twenty feet wide. A quarter of a mile below the falls mica schist and gneiss are seen to outcrop in the river. The strike is N. 68°E; dip south at a high angle. No. 227 (H). At the falls the rock is so much disturbed that no strike or dip can be ascertained. The general direction of the dyke seems to be N. 10°E. Nos. 228 (H) to 230 (H).

The falls are about forty-one miles up the river, in sec. 36, or sec. 35, 155-25. The water above the falls is quiet for five or six miles.

The banks and surrounding country for a short distance above are low and flat. Then the banks become higher and are occasionally thirty feet high; whether stratified or not could not be ascertained.

Less than a mile above the falls is an outcrop in the river of gneiss and mica schist. The strike appears to be E. 50° S. Dip S. W. at a high angle. No. 231 (H).

For the next nine miles the river is still with a moderately strong current. The banks are not over fifteen feet high; generally less than ten. They consist of stratified clay containing pebbles. A meander corner at the south side of sec. 34, 65-26, shows this place to be thirty-two miles, in a straight line, south of the mouth of the river. It is estimated at fifty-five miles by river.

In one or two places large masses of gneiss and mica schist are seen in the river just under the water. They may be in place. Limestone and Cretaceous shale are seen in small pieces in the banks. There is much good hard-wood timber, plenty of immense poplar and some large pine along the river. It is a good country for farming.

About eight miles farther is a bank where the clay beds are exposed. They consist of fine hard clay containing pebbles and a few boulders. The bank rises fifteen feet above the stream. Fragments of limestone and bluish-gray shale are seen in it. No. 232 (H). A meander corner is seen at the east line sec. 1, 152-25, which is sixty-four miles up the river. Very few boulders were seen in the banks for ten or fifteen miles along here. The river is remarkably straight, much more so than the Little Fork. A stream enters on the east side at about sixty-two miles.

For the next few miles (about seven) there is more current and the stream is more crooked than below. A stream enters on the west side at about 67 miles. No rock in place has been seen for miles.

The banks are all stratified clay containing gravel. Boulders begin to be more frequent. The banks are low and heavily wooded, and contain limestone and shale.

About five miles farther is a rapid and an outcrop of fine mica schist projecting a few inches above the water in the stream. This is about 72 miles up the river. The schist is scratched and smoothed in various directions, the main part of them being N. 10° E and N. 30° W. One or two small veins of gneiss cut the schist. This broad smooth exposure would be hidden if the water were a few inches higher, as the river is so muddy that nothing can be seen four inches below the surface. No. 233 (H). The course of the river along here is considerably east of south and much more crooked than before. A short distance above the last is much more mica schist. It has a strike N. 68° E. and very marked glacial scratches N. 60° W. It is quite hard in places and contains hornblende and chlorite, also garnets. The dip is N. W. at a high angle.

A little farther up the river on the east side the strike changes to N. 40° E. A dyke is then seen which is about ten feet wide and runs nearly north and south. The schist is hard, fine, siliceous and brittle next the dyke. Nos. 234 (H) and 235 (H).

On the right (west) side of the river is a bed of light-colored crystalline rock, with the constituents of granite. Only a few feet of it were visible; but it seemed to be three or four feet wide and to cut the schist. Nos. 236 (H) and 237 (H).

The banks continue to be low. They contain but little gravel and few boulders though the presence of quantities of both in the bed of the stream is evidenced by the frequent collisions between them and our paddles. The clay banks are about ten feet high, of hard clay, with pebbles scattered through it. In some of the banks there is a stratum a few inches thick of gravel and boulders about three feet from the top of the bank.

About five and a half or six miles farther up the stream is a rapid and at the head of it is a low outcrop of hard greenish rock. No strike or dip can be ascertained from the small amount visible. No. 238 (H). This is about 78 miles up stream, and 42 miles above the falls. The river is very crooked and still tends eastward. About a mile farther is a rapid in which no rock was seen but boulders.

About a mile and a half farther, in which distance there is considerable rapid water and a large number of boulders, is seen a fall in the river of about five feet. The rock is a hard, tough greenstone that has the appearance of trap. Portions of it have been moved on other parts and produced a slickensides and faint lines of schistosity. There are quartz veins in it, and also veins of light-colored siliceous rock and of calcite. The rock exposure is a hundred feet wide at least in any direction. Its longest outcrop is across the river about N. 80°E. Nos. 239 (H) to 239D (H).

About 40 rods above the falls south is an outcrop of a hard green rock similar to that at the falls. It might be called very fine diabase, but looks like the fine graywacke of Vermilion lake. No strike or general structure of any kind could be observed. No. 240 (H).

A sharp lookout was kept in the next seven or eight miles for Norwood's "ridge of gneiss",* sixty feet high, crossing the river. No ridge of any sort can be seen from the river, and no banks over twenty feet high. Few boulders are seen in this distance.

At the end of seven and a half miles, the foot of a rapid nearly one half a mile long is reached. At the foot of it is a bank of gravel and sand. It is a very different sort of bank from those seen below here. It is stratified, or partially so, but not horizontally nor all in the same direction. It looks like a stratified river deposit. Under it crops out a little fine bluish-gray clay, of which only a foot or two can be seen. This is supposed to be Cretaceous. No. 241 (H). There are many limestone pebbles in the bank, above the clay, but no shale is seen in it.

This rapid is over an immense number of boulders. Most of them are hornblendic gneiss, but other rocks are frequent. Many of the boulders are large and stick up several feet above the water. A short distance up the rapid is a small island which seems to be made of boulders and is covered with trees and bushes. All the rock that could be found on or around the edges of this island was boulders. This may be the "rock island" mentioned by Norwood.* A specimen from one of the syenite boulders 17 feet long, 7 feet wide and 4 feet thick, is No. 242 (H).

Above the rapids quantities of boulders are seen; while below only a few were encountered. The country does not seem to be of one general level as before, but is knolly. The banks are of sand and gravel and contain much more gravel than those below the rapids. This is about 95 miles up the river, probably in Twp. 62-25. It seems probable that the rapid mentioned above is on the boundary or shore of he glacial lake Agassiz, and that all of the river below this rapid is included in the ancient basin.

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* D. D. Owen's Geol. Sur. Wis. and Minn., 1852.

Five miles farther up is an Indian clearing and house. This is on what is called *Buskokagin* Indian reservation. Twp. 62-25.

The country appears to consist of knolls of till. Quantities of boulders obstruct the stream and form rapids at every bend.

Deer river enters the Big Fork just above the Indian's clearing. Four or five miles up Deer river is a dam and logging camp. The bed of Deer river contains hard, polished beds of stratified clay. The banks are somewhat clayey, but mostly gravel and sand.

The drift knolls rise thirty to fifty feet in the country away from the river and are covered with large pine. The drift contains many limestone pebbles.

In the bed of Deer river at a dam about half a mile from the Big Fork bed rock was seen. It is hard, green schist, that looks like greenstone. Some of it contains mica in very fine scales. The rock seen right at the dam did not contain any mica; that farther east did. Strike N. 36°—N. 40° E. Dip about vertical. Glacial scratches N. 80° W. to W. No. 243 (H).

About three miles up the Big Fork from the mouth of Deer river is a hard round exposure of green rock on the east side of the river. It contains pyrite in cubes. It also contains nodules of a light-yellowish color, some of them two inches in diameter. They seem to be feldspathic, and this may be the rock that Norwood calls "porphyritic greenstone."* No island such as he describes containing "hornblende slate" has been seen. Glaciation here is east and west, No. 244 (H). This is about 104 miles up the river. This rock much resembles the slates and greenstones at Thomson south of Duluth. The country is well covered with drift here—the river bluffs rising fifty or sixty feet above this outcrop of rock.

About two and one-half miles farther is an exposure of rock in a small island on the west side of the river. It is hard, jointed, green rock, much like the last. It contains considerable calcite in seams. No. 245 (H.)

Less than a mile above the last is a quantity of large, broken fragments of rock which seem to have been broken by blasting. It is trap or dioryte and varies in texture in going from north to south.

About five miles farther is a small exposure of a peculiar greenish rock. It is at the foot of Rice River rapids, three and one-half miles below Rice river, which enters the Big Fork on the east about fifteen miles above the mouth of Deer river.

This rock looks almost like a metamorphosed conglomerate. It is feldspathic and becomes felsitic a little farther south. It shows onl at the edge of the river, and specimens had to be obtained from unde water.

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* D. D. Owen's Geol. Sur. Wis. and Minn. 1852.

About fifteen rods up, on the east side, is another small outcrop of rock. This is hornblendic, epidotic rock that varies to syenite or dioryte and then to amphibolyte. It is quite a remarkable change from green schist to syenite. Nos. 247 (H), 248 (H), 248A (H) and 248B (H) illustrate this transition which takes place going south. At this place a portage of three-quarters of a mile was made around a log jam in the river.

A short distance farther up the river, on the same side, is another small exposure. This is feldspatic greenstone, quite jointed and hard to get at. No. 249 (H).

About seven miles farther up the river, 120 miles above Rainy Lake river, is a ridge of quartz dioryte on the N. W. side of the stream. It looks much like the rock into which the greenstone grades below here. No. 250 (H).

The river banks along here are lower and are swampy and marshy. Boulders are plentiful. This is at the west side of section 30, 61–26. A short distance above the last locality, which is N. 40° to N. 60° E. of this, is more similar rock on both sides of the river. This is in the east side of section 25, 61–27. The exposures rise but a little above the water. The feldspar is green and red.

About four miles farther are some large angular pieces projecting from the water and some rock in the bed of the stream which seems to be solid rock. This is a peculiar porphyritic rock that is almost wholly made of feldspar; but contains a little green material, perhaps chlorite or sericite. No. 251 (H).

About three miles above this is an outcropping of dioryte (?) on both sides of the river. It rises four or five feet out of water and extends nearly across the stream. It is No. 252 (H), quite similar to 250 (H). It is very siliceous and contains quartz geodes. No. 252 A (H). Glaciation N. 52° W. Twenty-four rods east in the woods the rock is finer grained and looks more like syenite. No. 253 (H).

Around the next bend in the river is a large exposure of rock which rises 15 feet or more above the water. Some of it is syenite and some looks more like dioryte. No. 254 (H). This a large outcrop of massive feldspathic rock that thus appears to be the direct product of alteration or metamorphism from the hardened green schists seen north of here. These schists become gradually feldspathic, hornblendic and siliceous, and develop into regular syenite. This is the last rock observed in ascending the Big Fork river.

About two miles above is a rapid over boulders. The river is winding and runs through swampy country most of the way. About a mile farther, 142 miles from Rainy Lake river, is a meander corner between secs. 4 and 5, 149-25. The land is flat and marshy, and the stream is nearly filled with manomin or wild rice. The river here is named Bowstring river on the goverment plats. It expands into a shallow lake filled with rice, in Twp. 149-27. Much splendid pine is seen on the shores of this lake.

No boulders or solid rock are seen along the shores. A few miles further is Kashebushkag (grass-spots) lake, so called from the large, round bunches of tall grass that grow in it. Just west of this lake is Round lake (Kawaie-gamak). After crossing this lake and searching for some time, a first-class portage is found three-fourths of a mile long, leading into a small lake whose outlet is to the south. This creek is very crooked and full of rice, but has much excellent pine along its banks, as has also Round Lake river and Kashebushkag lake.

Boulders are seen in this creek, which flows south, through one or two small lakes, into Winibigoshish. Limestone fragments are seen in the bed of this creek, and in the bottom of the deep pools are beds of extremely hard, bluish clay. The water was so deep that no specimens could be procured.

LAKE WINIBIGOSHISH.

The shores of this lake are low and marshy or sandy, with a few boulders. Some limestone pebbles are mixed with the rest.

At the dam at the lower end of the lake the shores are twenty-five feet high, of stratified sand.

MISSISSIPPI RIVER.

The banks of the river below lake Winibigoshish are of sand, sometimes twenty-five feet high, and sustaining a good growth of pine. A few large boulders of granite are seen in the river. Probably most of them were taken up to be used in the dams above here.

It is about 55 miles by river to the mouth of Pokegama lake. The river banks are generally of fine sand not over ten or fifteen feet high.

The river valley varies in width from half a mile or less to two miles. Few boulders or pebbles are seen.

POKEGAMA—(*The lake that lies with one end in the river*).

The shores of this lake are of reddish till five feet to thirty feet high, containing very few limestone pebbles. Many boulders are seen around the islands and on some of the points.

A trip was made to the south end of the lake and up on to the ridge in sections 22 and 27, 54-26. This ridge is covered with fine hardwood timber, oak, elm, yellow birch of immense size, sugar maple, etc. Boulders and pebbles are numerous all the way up the sides and on top of the ridge which is probably 175 feet above Pokegama lake. No rock in place could be seen. The ridge has the appearance of a moraine, the trees that have fallen having torn up boulders and pebbles and disclosed nothing but till below. Still the solid rock may be underneath at no great distance.

A few large pieces of limestone are seen on an island in the lake. The till is quite sandy and generally of a reddish-brown color, though some of it is decidedly yellowish. Pebbles of all ordinary kinds of rock are seen, and some peculiar varieties such as porphyritic greenstones and diorytes.

MISSISSIPPI RIVER.

A short distance before reaching Pokegama falls in the N. E. ¼ of N. W. ¼ sec. 13, 55–26, a ridge of quartzyte is seen on the south side of the river. It is twenty or twenty-five feet high and has been blasted out some to furnish rock for the dams.

This rock varies in color from white and yellow to green, red and almost black; and in texture from aphanitic quartzyte to coarsely granular sandstone. The general direction of the ridge is between N. 60° E. and N. 80° E. The top of it is thinly covered by drift and is on about the same level as the land south of it.

Pokegama falls are over this rock. The water here falls about seven feet in a slanting *chute* It is said that the falls were formerly much higher and have been much worn down in the last twenty years. The Indians call them Kakabikag, (rocky falls). They sometimes add a diminutive and call them the "Little Rocky falls." This rock is No. 256 (H). There are round nodules of iron sesqui-oxide in many of the pieces that have been blasted out at the falls. They are half an inch to an inch in diameter, and are more or less hard and siliceous. No. 257 (H). Some of the rock at the falls is exceedingly soft and will crumble in a person's hands. Most of it is quite ferriferous and the bands or lines of iron rust give an appearance of stratification in places. It appears to lie nearly flat with a low dip to the southeast especially noticeable where the water has decomposed it considerably. No 258 (H).

Portions of it contain a fine red clay supposed to be Catlinite. This occurs sometimes in thin scales or sheets, sometimes in round or angular lumps that evidently bear some relation to the ferruginous nodules mentioned above. Specimens of the quartzyte containing Catlinite (?) are No. 259 (H).

The drift below the falls contains many boulders. Grand rapids is over boulders that have been so much removed and cleared out that there is not much of a rapid there now. The upper part of the banks is composed of sand. This rests on hard clay beds. Springs of cold water come out on top of this clay.

PRAIRIE RIVER.

This stream enters the Mississippi three miles below Grand Rapids. About a mile up this river is a long rapid over small boulders. No solid rock is seen until the first fall is reached five miles above the rapids.

The river has a sluggish current between the rapid and the falls, and but few boulders are seen until nearly at the foot of the falls. Here there are many boulders of gneiss of all sizes. One boulder of limestone was noted. The fall is a long rapid, which descends about nineteen feet. There is one *chute* near the top, of about five feet. This fall is in the S. E. ¼, sec. 34, 56-25.

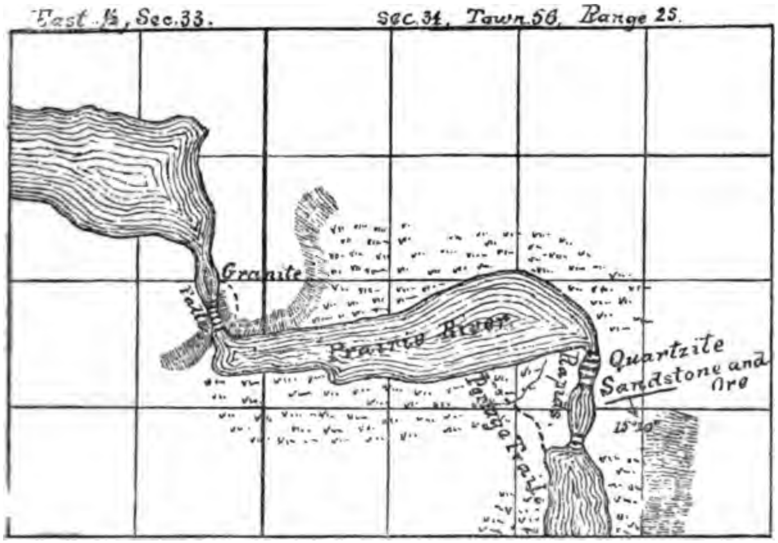

Fig. 10.—*Falls of Prairie river.*

Solid rock is exposed on the banks and in the bed of the river all the way up the rapid, and in the lake above, a distance of about one half mile. At the foot of the rapid the rock is red or reddish and more or less rusted with a quantity of iron oxide. Some of the rock is very good hematite. An analysis of ore [No. 260A (H)] from here, made by Prof. J. A. Dodge, resulted as follows:

Silica	8.25 per cent.
Alumina	Traces.
Peroxide of iron	92.08
Lime	Traces.
Magnesia	Traces.
Phosphorus	03
Sulphur	.01
Manganese	None.
Titanium	None.
	100.43
Metallic iron	64.45

thus "making a first-class ore, just above the lower limit of the Bessemer grade." These red ferruginous beds are not exposed for a thickness of more than two or three feet. Some of the rock is fine enough to be called jasper.

Above this the rock resembles that at Pokegama falls. It is seen most of the way up the rapids, and in the woods on both sides. It is in horizontal beds, which have occasional slopes in all directions, but have a general low dip to the southeast. Where the rock is decomposed it has the same appearance as at Pokegama falls. There are long scratches in the polished rock in the bed of the river that were probably caused by floating ice, log jams, etc.* Their direction is about north and south.

About two-thirds of the way up the rapid is a thin bed of fine conglomerate exposed on the surface for a space of several feet. It contains quartz, jasper, and greenstone pebbles, mostly less than half an inch in diameter. No. 262 (H). Some jaspery, hematitic rock, found about half way up the rapid, which contains chalcedonic quartz, is No. 263 (H).

There is no doubt that there is a limited quantity of good hematite here; but it is probably only in thin, horizontal strata, perhaps separated from each other by non-ferruginous beds, and of course would in that case be valueless. The true state of affairs could be determined by a shaft or test-pit.

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*At a subsequent visit, in October, 1888, the rock was exposed much better than at the time of the first examination, and the scratches were seen to cover the whole surface of the rock in a nearly uniform direction, and are undoubtedly glacial marks.

The quartzyte and hematite weather almost black. The ferruginous rock at the foot of the rapids weathers red. At the upper end of the rapid in the lake the quartzyte contains the iron ore disseminated through it in small spots. No. 265 (H). Several large, irregular shaped masses of gneiss at this fall have the appearance of being not far transported. No. 266 (H). This was found to be the rock which forms the "Upper Falls."

About a mile west of the upper end of the "Lower Falls" is the south end of the "Upper Falls." This rapid is about a quarter of a mile long and has rock walls on each side rising in places thirty or forty feet and only twenty or twenty-five feet apart in one place. This fall is in the east side of section 33, 56–25.

The rock at the foot of the rapid is a fine-grained, gray gneiss containing comparatively little mica and orthoclase. It is nearly horizontally stratified and varies from white to reddish in color. It changes in ascending the rapid, becoming coarser and containing more mica and feldspar. Some of it contains a very red feldspar; and small particles of sesquioxide of iron are seen in places. The mica is biotite. The horizontal gneissoid structure is very evident. Nos. 267 (H.) and 268 (H).

Veins of all thicknesses up to six inches of coarse, reddish granite cut the gneiss and run in crooked lines through it. It contains both muscovite and biotite and occasionally garnets. No. 269 (H).

There are many cracks or joints running in different directions but principally north and south. They appear to have been caused by pressure and slight movements of the rock upon itself. No. 270 (H). Calcite and gypsum are found in some of the seams.

The ridges that produce these falls run for some distance on each side of them in a general direction of about N. 70° E. They are more or less covered with a glacial drift containing many boulders and supporting a heavy growth of forest trees.

There is a lake about a mile long from east to west between the two falls. The land between the two ridges at each end of the lake is low, and no solid rock is visible. The quartzyte ridge can be traced for some distance on each side of the Lower Fall.

Going northeast from the Upper Fall through the N. W. ¼, sec. 34 into the S. E. ¼ sec. 27, 56-25, some variety is noticed in the rock.

About half a mile from the falls the gneiss has the same general appearance as at the falls, No. 271 (H).

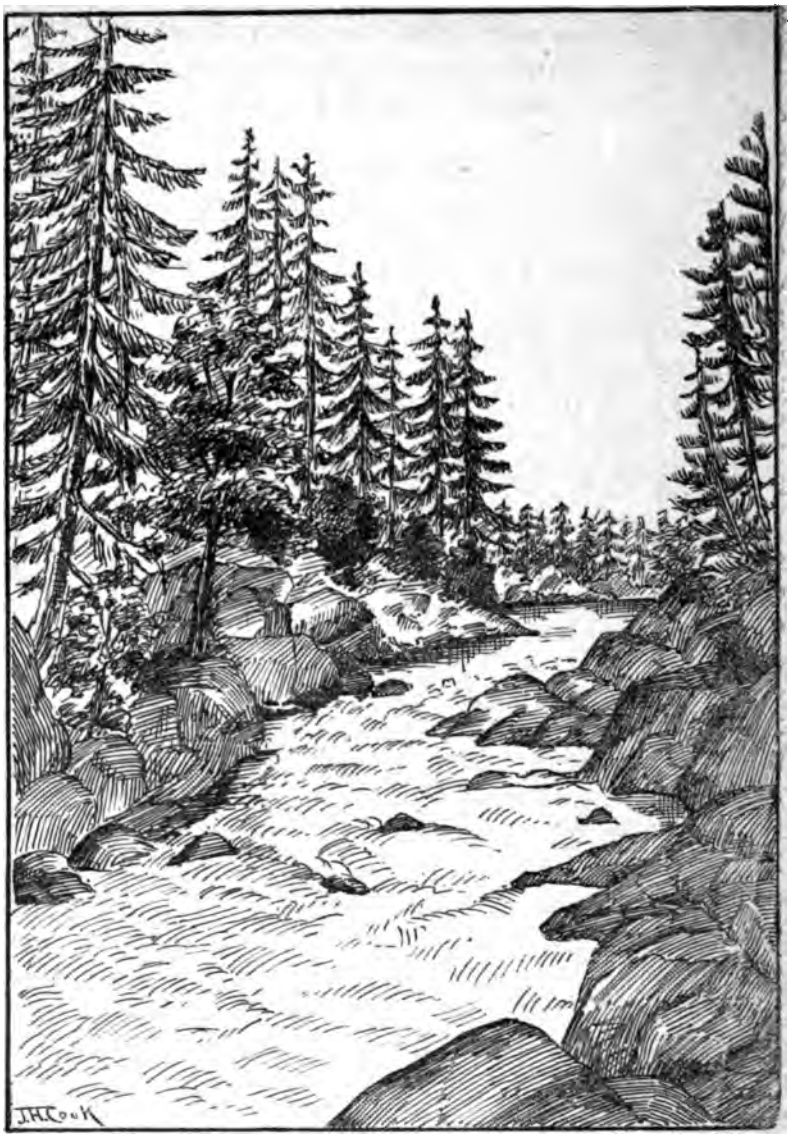

Fig. 11.—*Sketch of Upper Falls Prairie river. By H. W. Fairbanks.*

There is found a round knoll or part of a ridge of rock containing less quartz and some hornblende with only a little mica. This rock is pale greenish in color. It is in nearly horizontal beds and approximates syenite gneiss rather than true gneiss. No. 272 (H.) This rock has the same red veins penetrating it. Only a few feet from the last, the intervening space being obscured, is a small exposure of a dark green rock looking almost like doleryte, but hardly compact enough, and containing small lumps of fine dark rock like argillyte. No. 274 (H.)

In the S. E. ¼, sec. 27, 56-25, is found a low ridge of slightly porphyritic hornblendic gneiss. It is in mostly swampy land, with a thick carpet of moss. The rock is horizontally stratified, or nearly so. No. 275 (H.) It is cut by red, coarse muscovite granite. This rock all seems to have a low dip to the S. E. Whether the dip is sufficient to carry it under the quartzyte or whether it extends any farther south could not be ascertained. Much time was spent in trying to trace the rock continuously from the quartzyte to the gneiss. But there is a depression between the two ridges which is occupied in part by the lake, by a swamp at the east end of the lake and a covering of till at the west end. Both of these rocks, the quartzyte and the gneiss, are nearly horizontally stratified, both contain more or less sesquioxide of iron, and both seem to have a dip which would bring the quartzyte on top of the gneiss where it would naturally belong.

At the upper side of the "Upper Falls" the rock contains some beds that are quite hornblendic. Other beds at the same place consist of hornblende schist containing more or less mica. These beds are cut by red granite veins and generally lie nearly flat, but sometimes cut the gneiss almost vertically. The line of separation between the gneiss and hornblende schist is usually quite distinct. Nos. 276 (H), 277 (H) and 278 (H).

At the upper end of the Upper Falls, on the east side near the dam, the gneiss changes into a jointed, coarsely schistose rock that contains much red feldspar and a greenish-black mineral, perhaps chlorite. This rock seems in places to constitute a bed cutting or running through the gneiss, but the conclusion reached after careful examination is that it is in flat beds, and is a belt harder than the rest and therefore standing above it. The gneiss itself at this point contains considerable quartz and white and red feldspar. No. 283 (H).

It is noticeable that this gneiss here at Prairie River falls does not have the appearance of uniform gneiss. It looks lumpy and as if made from various materials. It seems as though it could easily become mica schist, hornblende schist, graywacke, quartzyte or iron re. Tendencies toward all these rocks are visible in it. The most ermanent and generally prominent feature is the nearly flat gneissic structure.* The gneiss is much coarser at the head of the Upper Falls than at the foot.

Above the falls the banks of Prairie river are composed of sand containing more or less gravel. Boulders are numerous and produce rapids in the river. The drift does not seem to contain any limestone. Some of the banks are of sand, fifteen or twenty feet high. There are many springs of cold water issuing near the bottom of these banks.

In the S. E. ¼ of N. E. ¼ sec. 5, 56–24, gneiss protrudes through the moss and soil in a swamp. It is in very many rough angular pieces of all sizes that seem to have been split up by the action of frost. It is all of about the same nature, fine biotite, muscovite gneiss. No. 279 (H).

Quite a ridge of gneiss similar to the last is seen in the S. W. ¼ of S. W. ¼ sec. 4, 56-24. It is found in large masses that have been split apart to a depth of ten feet, in places, by the action of frost. They are somewhat rounded and smoothed on top. No. 280 (H). This locality may be in the N. W. ¼ of N. W. ¼ sec. 9, 56-24. This rock is near the surface for a quarter of a mile or more south of here. The ground is high and covered with a good forest. Knobs of granite project here and there. No trap rock was seen, though it is marked on the government plats.

No 281 (H) is from the S. W. ¼, sec. 33, 57-23. It is gneiss; the rock lies in regular masses on the surface. It appears to be closely connected with the bed rock.

In the bed of Sucker brook, in sec. 27, 57-24, is found some fine, bluish-gray clay in beds of unknown depth. No. 282 (H). Much of this section of the country seems to be underlain by clay beds, as springs of cold water are very numerous.

MISSISSIPPI RIVER.

In Twp. 54-24 the banks of the river are 25 feet high or more. They are composed of sand for 15 feet from the surface. The rest of them is composed of fine, hard clay, red and blue, in thin beds. The top beds of this clay are red, and there are also thin, red layers in the blue strata all the way down. No. 284 (H).

This clay continues to form part of the banks where they are over ten feet high for twenty or thirty miles farther down the river (ten miles below the mouth of Swan river, in township 52-23). Most of it is bluish-gray clay and is more sandy than the red layers. A thin layer of fine sand separates each stratum of clay from the ones next to it. This clay forms the bed of the river in many places. It is so hard that one can hardly stick a knife into it. It is not in perfectly horizontal layers everywhere, but the strata undulate and have a wavy appearance in places, and again are flat or slightly inclined.

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*Mr. Bailey Willis in vol. xv, 10th Census, p. 460, describes this gneiss as being without bedding.

A short distance, perhaps ten miles, above Sand lake is the first rapid and first accumulation of boulders seen below Grand Rapids. From here down boulders are quite numerous. Below Sand lake the clay strata appear only occasionally and have a slightly different aspect, containing more sand. The banks are lower and all seem to be alluvial.

There were reports circulated at Grand Rapids of silver ore found in township 61-23. The locality was not visited, but a sample of the rock from there was obtained of the postmaster at Grand Rapids. This was assayed by Mr. C. F. Sidener, who reported "no gold or silver."

TRIP TO PELICAN LAKE.

The rock in the N. E. ¼ of the S. W. ¼, sec. 4, 63-18, is gneissic mica schist. It is cut by intrusions of gneiss and syenite gneiss. It rises forty of fifty feet above the stream connecting Hoodoo lake with Partridge lake, and above Hoodoo lake. There is no fall in the stream between these lakes, which is wide and dead water all the way. No. 286 (H) is from the above mentioned locality. There is very little rock exposed on the shore of Hoodoo lake. The schist in this region has a very gneissic appearance and might be called fine gneiss rather than schist. It contains both muscovite and biotite as well as hydromica.

In the N. E. ¼ of S. E. ¼, sec 5, 63-18, the rock is schist containing mica that is partly hydrated. It also contains some hornblende and is very siliceous. Small veins of quartz run all through the rock in the direction of the strike. There are also lenticular masses of quartz in the schist. Strike is about E. 20° S. Dip is S. 70° to vertical. There are intrusions of granite in the schist. Fine particles of pyrite are scattered through the rock. No. 287 (H).

A few rods west of the last, along the strike, the rock assumes a more perpendicular dip and contains much chlorite which gives place to hornblende a little farther west.

The schist here is much jointed and is composed almost wholly of hornblende. It is quite ferruginous and heavy in places, and disturbs the needle. Samples are No. 288 (H).

A little further west along the strike, which is in a general east and west direction, the schist becomes like syenite gneiss, and is finer grained. It rises in perpendicular beds sixty feet above the lake. Some of the thin beds are much more hornblendic than others; some contain both mica and hornblende. The whole hill is cut by intrusions of granite, intricately crossing and re-crossing each other. No. 289 (H). The intrusions contain thin veins of a hard, green mineral, probably epidote. There are small cavities in the hard crystalline rock, filled with a soft white substance, like kaolin. Parts of these intrusions are also felsitic.

Soft, red mica schist is seen at the portage near the west end of Hoodoo lake, N. W. ¼ of S. E. ¼, sec. 5, 63–18. Fine-grained siliceous mica schist is seen on the portage from Hoodoo lake to Susan lake, which lies just north of it.

No. 291 (H) is from a small island in the north side of Susan lake, in sec. 32, 64-18. It is fine mica schist, which assumes a gneissic texture on the same island. This schist dips S. W. 50°, and strikes E. 70° S. It is mostly quite solid and firm, and contains fine particles of pyrite. The features of the rock in this lake are the strike and dip. The latter is generally, at a low angle, W. S. W. The schist contains many wavy sheets or beds of gneiss. In one place there is a mass of hornblende schist, inclosed in the mica schist and cut by the same granite intrusions. It has the same strike as the mica schist. The continuation of it is covered on both sides, but later it can be traced for five rods, sometimes a foot thick, sometimes only an inch, running through the mica schist. This rock seems to be composed almost wholly of hornblende and biotite, with some feldspar. No. 292 (H). Some of it seems to contain graphite. No. 292A (H).

No. 293 (H) is from the S. E. ¼ of S. E. ¼, sec. 32, 64-18. It is mica schist, with thin sheets of green mica. The schist itself has a rosy or pink tinge. The rock in the southeast end of Susan lake is gneiss interbedded with schist. No. 294 (H).

ELBOW LAKE.

On the north side of the Portage from Susan lake to Elbow lake—probably in the N. E. ¼, sec. 32, 64-18—is a round point of mica schist and gneiss that projects into the lake a short distance. The strike is east and west. Glaciation is N. 26°E.

Twisting, winding veins of granite run all over the surface of this point. One intrusion about four inches wide (No. 1 in the sketch) runs with the bedding nearly straight for several feet, and cuts through a bed of gneiss (No. 2) two feet wide that cuts the schist into an irregularly shaped mass. The thin intrusion (No. 1) after conforming with the schist for a distance, turns off and splits up into thin threads, cutting the schist as well as the feelers from the gneiss bed (No. 2). No. 2 is also cut by a fine dark vein of granite (No. 3) that also runs across the beds of schist. No. 1 cuts both No. 2 and No. 3. It is pinker than the others, and is coarser at the edges than in the middle. No. 2 is coarser than Nos. 1 and 3.

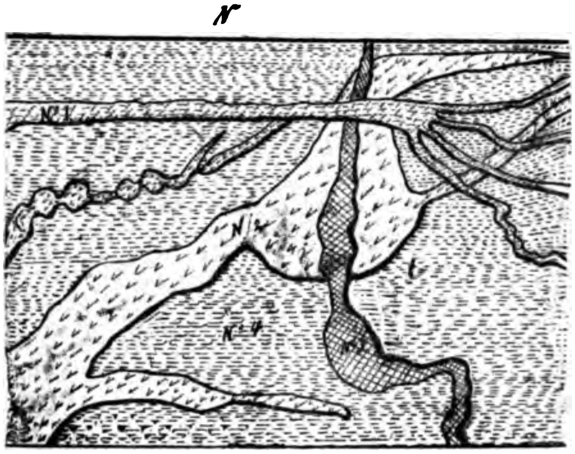


Fig. 12 —*Granite intrusions in mica schist. Elbow lake.*

Sometimes the beds of gneiss contain enclosed masses of mica schist which generally preserved the strike of the schist on both sides of the gneiss. The following diagram of such inclosed masses of schist was made from rock seen east of the round point on Elbow lake illustrated in the last figure.

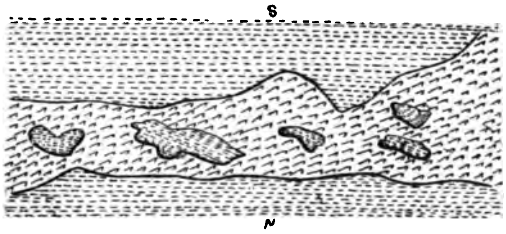


Fig. 13.—*Gneiss containing masses of mica schist interbedded with mica schist. Elbow lake.*

The dip is about vertical; sometimes a little one way, and sometimes the other. Many of the thin beds of schist are hornblendic as well as micaceous;—the hornblende crystals standing out on the surface and giving a black color to those beds. The rock is quite generally covered by moss and lichens when not obscured from view by overlying soil.

A sample of the mica schist from the south-east bay of Elbow lake is No. 295 (H).

A little north of the last the rock is a regular alternation of gneiss and mica schist in beds of variable thickness. The general trend is N. 80° E, and the prevailing dip is to the south, sometimes as low as 45°. There are also granite intrusions cutting gneiss and schist alike. The strike changes a little in going farther east, becoming about N. 60° E. Much more intrusive granite is seen. In some places it has flowed over the schist and lies unconformably upon its upturned edges. Much of the gneiss is fine and very micaceous; none of it is very coarse.

At the east side and end of the lake the gneiss lies nearly flat—quite so in places. It has been folded and bent in large waves so that it dips in all directions; now are seen the crumpled edges and again the convex tops of the distorted strata.

At the northeast end of the lake the strike of the gneiss and schist has changed to N. 20° E. Here it is impossible to tell which is bedded gneiss and which intrusive granite: it all seems to cut the schist in one place or another. Gneiss that seems to have flowed over on the upturned strata of mica schist is cut by granite intrusions that also cut the schist.

The flatness of the schist beds around the east and north end of Elbow lake is quite striking. The rock rises in bluffs forty feet above the lake; and granite intrusions can be seen cutting the schist and beds of gneiss at all angles from horizontal to vertical. Some of it is a fine breccia; but the most noticeable feature is the general horizontal position of the strata.

The gneiss and schist in the hills east of the northeast end of the lake are stirred and mixed most thoroughly. Gneiss and schist alike are bent and doubled on themselves as a piece of paper crumpled in one's hand would be. The gneiss is mainly composed of feldspar in very angular crystals, some an inch and a half long and of a red color. Much of the schist is hornblendic.

There is a dyke (?) of rock, similar to No. 292 (H), six inches wide running through the schist and gneiss uninterruptedly for a good many feet. Its course is N. 80° E. It is composed chiefly of hornblende, mica and feldspar. No. 297 (H.)

On the point which projects into the lake from the north side of the ake the rock is the usual mixture of micaceous and hornblendic schist nd gneiss. The gneiss being harder it is slower in submitting to the rosive action of the lake and the elements, and so it appears o predominate largely; but there is a fair proportion of schist with t. The schist lies in all possible positions and relations to the gneiss; ver it and under it, twisted around it and enclosed in it. The usual ntrusions of granite cut it in all directions. These are much more egular in their course and shape than the beds of gneiss. There are wo or three series of them, crossing and cutting each other in various directions. There is no uniform strike or dip to the strata here; ut the apparent tendency is to assume a north dip. The rock beomes more gneissic as we go north, and does not seem to be penerated by so many granite intrusions.

A little southwest of the last the solid rock rises up nearly 100 feet bove the lake. It is mostly gneiss of different colors and degrees of oarseness; some lying flat and some on edge cut by other beds in all orts of ways. Some of the main body of the rock is fine, gray biotite neiss in flat strata. It resembles the gneiss at the Upper Falls of rairie river. No. 300 (H). Some of it is coarsely granular, containg pink and white feldspar and mixed with mica schist. No. 301 (H).

No. 302 (H) is from a bay near the west end of the lake. It is the ark, fine, heavy rock composed mostly of mica and hornblende which as already been labelled No. 292 (H) and 297 (H). It is interbedded vertical strata with mica schist and gneiss; strike is N. 80° E. ust west of this the rock is similar but contains more feldspar. It is beds with gneiss and schist that contain both mica and hornblende, ut the mica predominates. Glaciation here is N. 28° E. The hills orth of the west end of Elbow lake consist of gneiss and hornblendic ica schist. They are immense rounded knobs of rock almost destite of vegetation and half covered with loose fragments of boulders nd *debris* from the hillside. They rise 150 feet above the lake.

ELBOW RIVER.

A small stream leaves Elbow lake, and after tumbling down a winding len around boulders and over solid rock for about a quarter of a mile beomes a small river with no apparent current most of the way to Pelican ver, into which it flows. This is Elbow river. There is a high ridge f hills south of it and considerable high rocky ground north of it. hen any large amount of the rock in this region has a uniform strike is about east and west. All of the rock around Elbow lake contains more or less hornblende, and most of it is decidedly acidic. The south shore of Elbow Lake follows the changing strike of the rock quite closely.

Going down Elbow river the first rapid is just at the outlet of the lake. The next is 2½ or 3 miles below. The hills here rise about 200 feet above the river on each side. They are almost bare knobs of gneiss, containing more or less schist interbedded with it. The hill on the north side of the rapid is called Bald mountain.

The country for a few miles around, as seen from the top of Bald Mt., is rough and hilly and probably all composed of this same formation. There is generally a strip of swamp along the river. The river bed is remarkably level for such a hilly country. Elbow river flows into Pelican river about two miles south of the east bay of Pelican lake—probably in sec. 18, 64-19. Samples of the gneiss from the top of Bald Mt. are No. 304 (H). The mica schist from the same place is No. 305 (H). The gneiss is hornblendic or chloritic, and is a fine-grained, siliceous rock with fine veins of a light green mineral running through it.

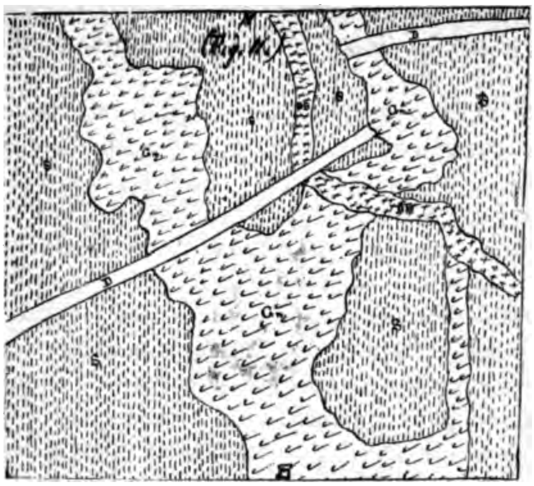
PELICAN LAKE.

The shores of this lake are not very high nor rocky, i. e., with solid rock. Most of the coast is either sandy or boulder-bound.

Pink gneiss is found in the N. E. ¼ of S. W. ¼, sec. 2, 64-20 It grades into mica schist in the immediate vicinity. The apparent dip here is south, but there is so little continuity in strike or dip that the general direction cannot be determined. Nos. 306 (H) and 307 (H). The south side of the point at the same place consists of beds of mica schist and gneiss that dip west and strike north and south. The schist is hard and fine-grained; the gneiss, gray and fine. No. 308 (H).

The island in the N. E. ¼ of S. E. ¼, sec. 3, 64-20, is composed of gneiss and schist and granite intrusions. The schist is both micaceous and hornblendic. The general strike is north and south, with a high dip to the west. The surface of the rock presents a most intricate commixture of veins, dykes, beds of schist and gneiss and granite intrusions. The last thing to come in was a small dyke of greenstone about three inches wide, running N. 30°E. It cut all the rest, but has been faulted off two or three feet since, and thus been changed in its direction.

Samples from the dyke are No. 309 (H.). It was traced for about three rods. Glaciation here is N. 36° E. At the same place there is a



14.—*Pelican Lake. Gn., gneiss. S., mica and hornblende schist. D. B., granite intrusion. D., small dyke of greenstone.*

d of greenish rock composed of mica, hornblende, feldspar and ıaps quartz, running through the rock in an east and west direc- . Streaks or threads of gneiss run all through and across it, and it a mottled appearance. It is about six inches wide and can be ed in a straight course for five or six rods. It maintains about same thickness during this distance. Where it passes through st there is generally a line of granite to separate it from the st. Where it cuts gneiss there is no distinct line of separation, the gneiss runs right down into it in the threads spoken of above. dark parts of this band of rock have a kind of schistosity in the ction of the vein.

he island near the centre of sec. 3, 64-20, is composed of the same ture of gneiss and schist and rises 50 feet above the lake. There long, smooth beds of rock which is half gneiss, half schist, on the t side of the island. These beds strike north and south and dip 64°. Much of the schist contains both hornblende and mica, and e of the gneiss is syenite gneiss. Occasionally dark, hornblendic : is seen, just as much bedded as the rest and evidently part of the ıation, but looking much more like eruptive rock. Some of it tains round grains and feldspar that look like amygdules. Nos. (H) and 310A (H).

. the N. E. ¼, sec. 12, 64-21, the rock is massive gneiss. The only s of mica schist are a few small lenticular masses of it, four to six es long which are enclosed in the gneiss. The rock is in low, flat outcrops. It contains hornblende and is somewhat porphyritic. No. 311 (H). It does not exhibit any granite intrusions nor other rock cutting it in any way. The same rock appears on the next point to the west, and here contains masses of mica schist, 12 to 14 inches long. It is also more porphyritic, containing orthoclase crystals 1¼ inches long.

The point in the N. E. ¼ of N. W. ¼, sec. 12, 64-21, is composed of this same rock. It contains a few masses of hardened mica schist two or three feet in diameter.

No. 312 (H). This rock is very similar to that which forms the falls at Fort Francis; the points of resemblance being its porphyritic nature, the presence of hornblende crystals as well as mica, no gneissic structure apparent, enclosed masses of mica schist, and position to the west of a disturbed region of gneiss and mica schist. It is probably the continuation of the same belt of rock as that at Chaudière falls. Immense, rounded pieces of this rock lie on the surface, some of them twenty feet in diameter.

No. 313 (H). is siliceous gneiss, coarse, granular and white. It occurs in thin beds in the mica schist on a point in the N. E. ¼ sec. 35, 65–20. On one side of it is mica schist with the biotite in round spots. The strike of the gneiss and schist here is north and south; dip at a high angle to the west. The gneiss predominates and is largely in thick beds. Both gneiss and schist are penetrated by granite intrusions that run for the most part east and west. These are very siliceous, contain white orthoclase and have an indistinct gneissic arrangement of the mica. No. 314 (H).

A small island supposed to be about in the S. E. ¼ sec. 26, 65–20 is composed of gneiss and hornblendic mica schist. Strike is N. 30° E., dip N. W. 75° more or less. Glaciation N. 30° E.

The beds of hornblendic mica schist are more decomposed than the rest of the schist.

One of these beds of schist cuts into the mica schist proper in some of its curves, for it is not quite straight though it follows closely the bedding of the mica schist, and is cut by the same granite intrusions as the mica schist. No. 316 (H). The specimens are from the hardest part of the bed, which is about six inches thick and has a gneissic arrangement of the minerals.

The next point to the northwest, about a quarter of a mile, is composed of gneiss and schist; the latter containing more or less hornblende all through it. The strike varies from N. 30° E. to N. 50° E. There is a high dip to the N. W. Glaciation N. 24° E. The schist is dark, hornblendic rock containing vitreous quartz grains and apparently but little feldspar. No. 317 (H). Some of the schist is harder and finer and less schistose than the samples. Much of it contains fine particles of pyrites.

The extremity of the point consists almost wholly of gneiss enclosing large masses of schist. Some of the gneiss is quite coarse, containing feldspar crystals over two inches long. Much of it looks like the coarse gneiss seen on Rainy lake, and some of it is pegmatitic. The finer gneiss contains hornblende as well as mica.

On one point in section 26, 65–20, the gneiss contains pockets of amphibolyte (?). They are round or irregularly shaped masses that have no resemblance to the gneiss and no visible connection with the schist beds or any other beds. They are simply enclosed in the gneiss. No sample could be obtained.

Just across the bay from the last point, to the north, the rock of the point is half way between mica schist and gneiss, but looks on the whole more like schist. It contains and lies along-side of beds of hornblendic mica schist such as is commonly found imbedded with gneiss in all this region. They are both cut by intrusions of granite. Thus we have here, instead of gneiss proper folded around mica schist or squeezed into it in a plastic state, mica schist—for it is that rather than anything else—enclosing and interbedded with irregular masses and strata of entirely different mica schist. No. 318 (H). This is somewhere near the N. W. ¼, sec. 26, 65-20. The general strike is about N. 20° E.

In the bay north of the last is a small rock island composed principally of gneiss. The enclosed mica schist is like No. 318 (H) and not like the more schistose schist with which that is associated. The schist and gneiss on this island are cut by an irregular intrusion varying in width from four to ten inches. It is noticeable that the intrusions which seem to have been latest and have cut all the rest are generally pinkish or reddish; while the bedded gneiss is white or but slightly pinkish, as a rule; though some of it is red rather than pink.

On this same small island the gneiss that conforms with the beds of schist for a short distance and is cut by the granite intrusion mentioned above, in its turn strikes off in a mass two feet and more in thickness, cutting through the schist—or at least across the strata, and constituting what might be termed a "dyke-bed" without being paradoxical.

The south side of the small island just west of the last is composed for the most part of handsome gray gneiss, slightly porphyritic. It is cut by the usual granite intrusions. No. 319 (H) is a sample.

On the shore of the mainland about 100 paces north of the island the rock rises 30 feet above the lake. It is mica schist and syenite gneiss with granite intrusions. It contains varying amounts of hornblende and grades in places from syenite to a dark, heavy, fine-grained rock almost all hornblende. It seems to contain some epidote. No. 320 (H).

For some distance along the shore to the west the rock is syenitic gneiss and mica schist.* A little farther along some immense masses of schist and gneiss stand up in the water near the shore, fifteen feet above the surface. They seem to have constituted one enormous boulder, now split and broken into several irregular, jagged masses.

The large island southwest of the last-mentioned locality presents an appearance similar to that of the coarse gneiss at the east end of Rainy lake. It is a mixture of coarse gneiss and mica schist. The schist predominates at the southwest end of the island. The strike is N. 20° E. Dip, W. N. W. 70°. The backbone of the island is principally gneiss, containing a little mica and hornblende schist in irregular masses and short beds. This gneiss is very siliceous, the coarse, vitreous quartz lying in it in masses several inches across. The feldspar is pink or white orthoclase, and is also very coarse; the largest crystals being over six inches long. The mica is muscovite; and scales two inches square can be obtained.

The gneiss incloses masses of hornblende schist. Samples are No. 321 (H). The mixture of mica in fine scales, and quartz in small grains, such as seen at the east end of Rainy lake, is found here, too. Perhaps this may be called greisen, but it does not seem massive enough to answer the usual definition. Some of the large feldspar crystals here contain quartz arranged in such a way as to form graphic granite. At the northeast end of the island there are siliceous beds in the schist containing pyrite, hornblende, malachite, chalcopyrite and a greenish-yellow mineral that was not determined. No. 322 (H). These beds are a foot or two feet wide, and continue for some distance, disappearing under the lake. The coarse gneiss here contains some biotite, as well as muscovite.

On the large point west of here is found the usual mixture of gneiss and mica schist both containing more or less hornblende. Strike is N. 35° E. Some of the schist enclosed in the gneiss has been so much changed and resembles the gneiss so closely that one is hardly able to discern the outlines of the former schist masses. Much of it is exceedingly hornblendic.

On the hill north of the point there is a breccia. It is a gneissic schist containing angular masses of hornblendic schist of all sizes up to two or three feet in diameter. Many of them have their longest direction across the schist beds. They seem to be much metamorphosed. The breccia also contains pieces of gneiss a foot long.

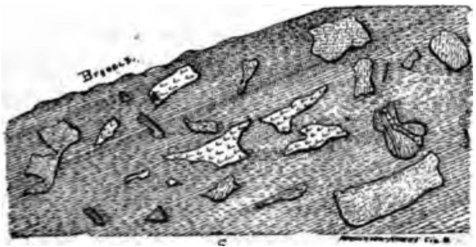


Fig. 15.—*Breccia. Pelican Lake.*

There are also in this breccia pieces of schist with gneiss running through them. There is a schistose or flowage structure running N. 35° E., and conforming somewhat to the shapes of the enclosed masses. This breccia extends nearly to the south end of the point.

The island just west of this point is composed mostly of micaceous, porphyritic syenite very poor in silica. It is massive and contains large irregular masses of mica and hornblende schist and gneiss. It has a contact with rocks similar to those enclosed in it, on the east side The direction of this contact is N. 20° to N. 24° E. In some places this rock resembles a coarse breccia, and elsewhere a conglomerate, the faint outline of formerly enclosed masses being visible. It has the appearance on the surface of having been heated to a boiling condition, and the uneven surface covered with curved lines and half-broken bubbles reminds one of oat-meal when cooking. It is cut by one or two narrow granite or rather granulyte intrusions. It also contains a few masses of red granulyte wholly enclosed in it. When it has been washed and weathered by the lake a schistose structure or something similar appears, the rock weathering in wavy lines and sheets.

The small island nearly a mile west of the last consists of pyritiferous, micaceous, garnitiferous, chloritic (?) syenite gneiss. The rock that lies to the west of this and is similar to the Fort Francis rock grades into this and into rock more hornblendic than this. This rock is all laminated in thin sheets having a low dip to the north. Nos. 325 (H) and 325A (H).

In section 36, 65-21, the whole shore, where it is high, is formed of the Fort Francis rock and its variations. The main part of it is quite similar to that which forms the falls at Fort Francis, but much of it is similar to No. 325 (II). It contains masses of pure, unchanged mica schist ten, twelve and even forty feet across. This schist is cut by granite intrusions and stands for the most part in vertical beds. Some of the mica schist inclusions are very much smaller, only six inches wide and two feet long or less. The schist has a very abrupt contact with the rock in which it lies. There are also inclosed in this rock numerous rounded and irregular pieces of rock quite similar in appearance to the main part of the rock, but generally more hornblendic. The inclusions are porphyritic and in other ways have a close resemblance to the rock which contains them, and yet they are decidedly different and probably were much more so formerly. The granite intrusions may be, and probably are, stringers from the main mass of the rock. The mica schist which is contained in this rock has small round "geodules" on the surface. They are little geodes having a quartz crust with garnets inside. One enclosed mass of schist is cut by a small dyke of trap which has a slight schistose structure. The glaciation here is finely marked N. 28°E.

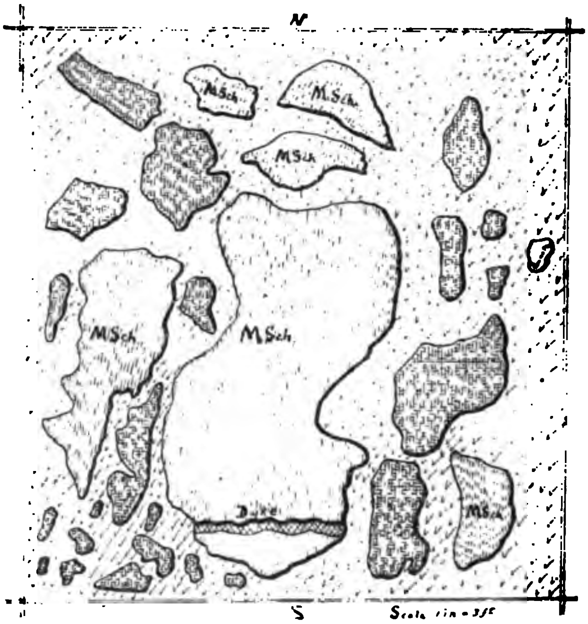


Fig. 16--*Breccia. Pelican lake.*

In the N. E. ¼ sec. 35 (?) 65-20, the gneiss and mica schist are cut by granite intrusions. Some of them are garnetiferous. Tourmaline crystals were found in the gneiss which is interbedded with the schist at this point. The rock is mostly fine gneiss. One of the large granite intrusions on the east side of the point consists largely of pegmatyte. This looks much like the coarse gneiss seen at Rainy lake. The trend of the graphic granite intrusion is N. 25° E.; width, feet; length of exposure, 150 feet. It contains muscovite crystals 2½ inches across. No. 331 (H.)

In the N. W. ¼ sec. 36 (?) 65-20, the rock is principally mica schist and interbedded gneiss. Irregular masses of a greenish, heavy rock, consisting mostly of hornblende, are contained in the gneiss. These masses are not over two feet long, and have an abrupt contact with the gneiss.

In the N. E ¼ sec. 36 (?) 65-20, the rock is principally mica schist containing some very even beds of gneiss and cut by granite intrusions running directly across the strata.

NET LAKE.

This lake is reached by making a four-mile portage from Pelican lake and descending a small stream nearly to the lake. The name of this lake, *Sabikweness*, signifies a fish-net; hence this name should be spelled with but one *t*, *Net*. The lake is almost entirely surrounded by swamps and is shallow so that a landing place is hard to find.

In only one place near the lake was any considerable exposure of rock seen. This is on a small island near the east side of the lake, just west of the Indian village. This island is composed of mica schist and interbedded gneiss cut by granite intrusions. The whole is then cut by a large dyke of greenstone from which stringers have been sent out across and through the other rock.

The west and north sides of the island are beautifully polished by glacial action, the striations running N. 20° E. to N. 24° E. The strike of the schist is N. 58° E. The direction of the dyke is about north and south. The dip of the schist is about S. 70°. There is much magnetite in the dyke-rock. This dyke cuts the granite intrusions and contains a few feet of one of them in it lengthwise.

The first solid ground south of where the river enters the lake on the east side is now cultivated by the Indians for a potato-patch. It was formerly the site of an Indian village; and many chips of flint and quartz as well as broken pottery and fragments of copper are to be found there. A few scrapers and imperfect arrow-points and knives were found here. The Indian who owns the potato patch says that he has seen quantities of arrow-points, but has never preserved any.

The portage from Pelican lake is about four and a quarter miles long. It is a good trail and leads to a small stream about two miles from Net lake. There is not much difference in the elevation of the two lakes, Net lake being a little lower if anything. The country between them is covered with drift for the most part; many large boulders and much gravel and sand are seen, but little or no solid rock. The hills north and northeast of Net lake contain much rock and so probably do the hills south of the lake, though they are said to consist only of boulders and drift material. Solid rock crops out in the midst of the Indian village at Net lake. It is mostly mica schist containing round or lenticular masses of gneissic rock.

TROUT LAKE.

The stream from this lake into Vermilion lake is a short one. It is quite rapid and is full of boulders and loose fragments of rock. The remains of an old water-wheel and stamp-mill are visible at the foot of the rapids. Angular masses of white quartz lie around. They contain pyrite and siderite. No. 333 (H).

The rock in the river channel is a mixture of mica and hornblende schist and gneiss. There are fine veins of red feldspar penetrating the rock in all directions. Most of the gneiss contains both orthoclase and plagioclase and more or less pyrites. The general strike seems to be east and west. Nos. 334 (H) to 337 (H).

The point in the S. W. ¼ of N. W. ¼ sec. 19, 63-15 is composed almost wholly of mica schist. There are a few narrow veins or stringers of gneiss running through it in various directions, and one or two granite intrusions of considerable thickness. The mica schist here does not seem to contain any hornblende.

In the N. W. ¼ of N. W. ¼ sec. 19, 63-15, the rock is mostly a fine, gray, biotite gneiss, slightly prophyritic and containing irregular inclusions of mica schist. No. 338 (H). On the north side of the point at the same place the rock is syenite gneiss in nearly flat beds. No 340 (H). The schist with which it is bedded and into which it graduates is also hornblendic. The gneiss is pyritiferous. There is heavy covering of drift here and many boulders lie around.

In the S. E. ¼ of N. E. ¼ sec. 13, 63-16, there is an exposure 20 feet long of flat bedded gneiss and mica schist. It is in bluffs 15 feet to 20 feet high. The gneiss and schist grade into each other and

uate in beds of all thicknesses up to three feet. Most of it is fine-
ained and more or less decomposed. No. 341 (H). These horizon-
l beds of gneiss and schist are cut by one or two nearly vertical
anite intrusions. No. 342 (H). The feldspar in both the gneiss
d granite is yellowish-white, and some of it is iron-stained. They
th contain more or less hornblende.

In the S. W. ¼ of S. W. ¼ sec. 13, 63-16, is a large, low exposure
gneiss and mica schist interbedded in vertical strata, and cut by
rtical granite intrusions from an inch to four feet thick, running in
directions through and across the beds. Strike is E. 54° S. The
hist is typical, biotite mica schist. The gneiss is fine-grained yellow
ck, similar to most of that in this region. Following this along the
ore in a southeasterly direction we soon come upon a perpendicular
ll of rock with a smooth face twenty feet high and one hundred
t long. This looks like a wall of masonry made of thin slabs laid
rizontally. On careful inspection it appears that most of the gneis-
structure and the arrangement of the minerals in lines and bands
vertical, and the beds are laminæ or sheets instead of strata. In
ch of it there is no gneissic structure evident. In places the
eissic structure dips S. W. 45°. This rock is hornblendic as well
micaceous and contains granitic veins. No. 343 (H). The direc-
n of the face of this wall is E. 70° S., and the general direction of
e gneissic vertical beds in it is about the same, some being however
40° S. At the edge of the water this appearance of laminæ disap-
ars and the rock seems to be as usual in vertical strata. Quantities
boulders and pieces of the adjacent rock line the shores of this lake.

The rock on the point in the S. W. ¼ of the S. E. ¼ sec. 14, 63-16,
gneiss and syenite gneiss containing a little schist, both mica and
rnblende. It seems to be in vertical strata. The syenite gneiss
ntains rounded or lenticular lumps or nodules of actinolite mixed
th a little mica. These nodules are four inches long, on an aver-
, and vary from light, grayish-green to greenish-black in color.
ey are much softer on the exterior than a short distance within.
e hornblende on the exterior is altered from some softer mineral.
s. 345 (H) and 345A (H).

n the N. W. ¼ of S. E. ¼ sec. 14, 63-16, the shore rises up almost
pendicularly for forty feet. It is mica schist containing a little
eiss. It is all pervaded by more or less hornblende. The strata
much disturbed here, and have no permanent dip. The strike is
40° S.

n the N. W. ¼ sec. 14, 63-16, the rock is principally a reddish, biotite gneiss, some of it quite coarse and containing pyrite. It lies across the mica schist beds, which are vertical for the most part, but have been much distorted in places. No. 346 (H). This reddish gneiss is itself cut by thin, light yellow or white granite veins.

Red chlorite gneiss is found in the S E. ¼ of S. W. ¼ sec. 15, 63-16. It occurs in vertical beds with strata of micaceous, hornblendic schist. Some of the beds are bent considerably and have a low dip to the north.

Near the centre of sec. 15, 63-16, the bluffs rise 60 feet or more vertically or in overhanging masses. It is principally mica-schist with some gneiss and a few veins of pyritiferous quartz. The schist itself is gneissic and almost massive; it is in such thick beds. Where there is any bedding structure visible it is wavy and distorted.

In the N. E. ¼ of S. E ¼ sec. 10, 63-16, the granite shores rise 40 feet above the lake in smooth, sloping ridges. Hornblende and a few other accessory minerals are present. In places the granite is quite coarse, orthoclase crystals four inches long being noticed. Some of it is pegmatitic. In some of this coarse granite the muscovite scales are set in or surrounded by quartz. Nos. 348 (H) and 349 (H).

From here north the shores seem to be wholly granite, no schist being mixed with it. It is all decidedly acidic and does not contain much mica. The feldspar is orthoclase. It is jointed in various directions. Sometimes it seems to lie nearly flat, sheets of it lying over each other, dipping to the southeast. Granite from the S. E. ¼ sec. 11, 63-16, is No. 350 (H).

Syenite is found in the N. E. ¼ of N. W ¼ sec. 11, 63-16. It contains red orthoclase, dark hornblende, and but little quartz. Epidote is a common ingredient. It has much the same appearance and manner of occurrence as the granite. It is inclined to be porphyritic in places. No. 351 (H).

Across the bay in N. E ¼ sec. 11, 63-16, the rock appears to lie in flat beds. It is gneiss with about equal amounts of mica and hornblende. Some of it is almost schist, and some is granulyte. It is cut by intrusions of granite. No. 352 (H).

In the S. E. ¼ of N. E. ¼ sec. 11, 63-16, the rock is fine, gray, biotite gneiss, containing plagioclase feldspar. It is quite firm and solid, but contains mica schist beds and lumps in which the strata run nearly north and south. Glaciation is N. 16°E. No. 353 (H). Portions of this same gneiss are very coarse, and the feldspar is orthoclase with the pegmatitic character.

Low, flat exposures of granite or gneiss are seen in the N. E. ¼ of sec. 2, 63-16. It is mostly fine-grained rock similar to 353 (H). It has bands of coarse granite running through it or lying on the surface. The line of contact or of separation from them is indistinct. Most of it has the appearance of being in beds dipping to the southeast at an angle of 30° or less. But in some of it there is an indistinct gneissoid structure which is about vertical. The shores are piled up for about ten or fifteen feet back from the lake, by the action of the elements, with masses of the subjacent rock and with boulders of granite. The gneiss contains a little hardened schist, and sometimes approaches the fineness of schist itself; but generally it is coarse, firm and compact.

Low exposures of porphyritic, micaceous gneiss are seen on the point in the N. W. ¼ of N. E. ¼ sec. 35, 64-16. In places it assumes the character of a breccia, and contains angular masses of hornblendic rock similar to that at the west side of Pelican lake.

Much fine pine grows around this lake. The water is clear and the lake shores and islands are beautiful. In many places, however, low reefs of rock extend out into the lake but a short distance below the surface of the water; thus making it difficult as well as dangerous for a canoe to land. In fact all of the shores have a very gradual slope into the lake.

A large exposure has been caused by fire in the S. E. ¼ of S. W. ¼ sec. 26, 64-16. It is gneiss, partly fine and partly coarse. Part of it is mica schist and part half-way between schist and gneiss. Coarse masses of iron-stained quartz are seen here; also some coarse feldspar. In all this region there is a more or less striking appearance of horizontal lamination in the rock. In almost every place careful examination reveals the fact that the rock has a gneissic texture that is vertical or nearly so. Also when any schist beds lie in the gneiss they seem to be in vertical strata.

The point in the west half of N. W. ¼ sec. 30, 64-15, is composed of gneiss and mica schist rising about 40 feet above the lake. At this place there is also a good display of the horizontal laminæ and vertical gneissic structure. The thin beds of schist which are in the gneiss are bent and doubled up like a letter *S*. The general strike is east and west.

There is a most enormous pile of "cobblestones" here. Just to the southeast of the long sand beach in the S. E. ¼ of S. E. ¼ sec. 24, 64-16, is a pile of them 20 feet or more in hight and extending for 200 or 300 paces along the shore. They are rounded and polished nicely and are from four inches to a foot in diameter.

At the north end of the lake the rock becomes more regular in its bedding and dip. The latter is north, at a high angle. At the very end it is mostly gneiss; but contains more schist or gneissic schist than the gneiss a mile or two south. Glaciation in the N. E. ¼ of S. E. ¼ sec. 18, 64-15, is N. 36° E.

Coming south through secs. 30 and 31, 64-15, the beds of gneiss and schist gradually become more and more distorted and irregular. The dip gradually goes from vertical to horizontal, and the strike is extremely variable. The beds are about horizontal in the S. W. ¼ of of N. E. ¼ sec. 31, 64-15. They are cut by vertical granite intrusions. In the N. E. ¼ sec. 32, 64-15, there is considerable mica schist, quite regularly interbedded with gneiss, having a strike E. 60° S.; dip, N. 60°.

In general. This lake lies on an anticlinal. The flat-lying beds are in the middle or on the top of this anticlinal, and the strata dip north at the north end and south at the south end of the lake. The bays and general contour of the lake do not conform with the general strike of the formation, showing that the rock is very irregular in its bedding and dip.

Much hornblendic rock is seen on the west side of the lake and hardly any on the east side. Much fine pine grows around the lake. Most of it is taken by pre-emption. The shores, as said above, are wretched for landing, large piles of boulders and loose masses of rock extending far out into the lake from nearly every part of the shore.

ELEVATIONS FURNISHED BY MR. WARREN UPHAM.

	Ft above the sea.
Rainy lake,* low and high water, approximately 1115-1120; mean	1117
Rainy river, rapids ½ mile long, just below Rainy lake	1117-1114
Rainy river, Chaudière falls, at Fort Francis, descending 23 feet	1114-1091
Lake of the Woods, low and high water, 1057-1063; mean.	1060
Bowstring lake, determined by U. S. engineers	1321

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*Hinds' *Narrative of the Canadian Exploring Expeditions*, London, 1860, vol. ii, pp. 399-402. Corrected by Upham through comparison with survey of C. P. R. R.

On Bowstring river.

	Miles from mouth of Bowstring river. (Whittlesey.)	
Head† of "fall of 6 feet over trappose rock" estimated about 70 ft. above the mouth of this stream.	82	1240
"Rapid of 4 feet over hornblende slate"	75	1225
"Fall of 29 feet over gneiss and mica slate"	45	1179–1150
Mouth of Opimabonowin river	40	1140
Junction with Rainy Lake river	0	1085
Red lake, approximately	..	1150

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†Whittlesey's *Report of Explorations in the Mineral Regions of Minnesota*, 1866. Corrected by comparison with leveling observations.

LIST OF SPECIMENS COLLECTED BY H. V. WINCHELL DURING THE SUMMER OF 1887.

LITTLE FORK RIVER.

No. 75 (H). Massive, green dioryte with a little biotite (?).

On north side of river about two miles below Wakemaup's portage.

No. 76 (H). Siliceous mica schist containing dolomite or calcite. From Rapid No. 1 three miles below last.

No. 76A (H). Biotite granite containing masses of muscovite granite, also containing calcite. Same locality.

No. 76B (H). Sample of schist similar to 76 (H); but containing grains of vitreous quartz. A little south of last.

No. 77 (H). Tough, massive, crystalline rock, containing magnetite. Underlies Rapid No. 1.

No. 78 (H). Mica schist containing also hydromica. From Rapid No. 2, four miles below last; three-quarters of a mile above the mouth of Rice river.

No. 79 (H). Siliceous schist. From Rapid No. 3, just below the confluence of Little Fork and Rice rivers.

No. 80 (H). Mica schist cut by gneiss. South side of river, three miles below Rapid No. 6.

No. 81 (H). Greenish mica schist containing pyrite. North side of river, four miles below last.

No. 82 (H). From "Big Falls" of Little Fork, about a mile below last. Fine-grained, compact, green schist; much jointed and presenting many different aspects in different strata.

No. 82A (H). A greenish-black mineral found in seams and joint of last.

No. 83 (H). Micaceous syenite gneiss containing lumps of a gree material. Two miles below last.

No. 84 (H). Drift limestone from a gravel bank about a mile an a half below Rapid No. 10.

No. 85 (H). Clay concretions from clay bank on north side of rive about three-quarters of a mile below Rapid No. 12.

No. 86 (H). Pophyritic garnetiferous, micaceous syenite. From Rapid No. 13, half a mile below last.

No. 87 (H). Fossiliferous drift limestone. From Rapid No. 17, about three miles and a half below the mouth of Sturgeon river.

No. 88 (H). Syenite gneiss. Just above Rapid No. 19. Graduates into greenish, hornblendic mica schist containing little quartz.

No. 89 (H). Fine, green schist, hardened and jointed. From Rapid No. 20.

No. 90 (H). Fine, light-colored dyke rock, cutting last; composed of quartz, feldspar, mica, hornblende and garnets.

No. 91 (H). Mica schist. From south side of river just above Rapid No. 22.

No. 91A (H). Mica schist, different from last and enclosed in it.

No. 92 (H). Fossiliferous drift limestone from below Rapid No. 27.

No. 93 (H). Lignite. From bed of a creek that enters on the east side of the Little Fork a short distance below Rapid No. 27.

No. 94 (H). Cretaceous shale. From same locality.

No. 95 (H). Shale containing fossils. Same locality.

No. 96 (H). Shale containing gravel. Same locality.

No. 97 (H). Shale containing crystallized aragonite.

No. 98 (H). Drift conglomerate from the same creek-bed.

No. 99 (H). Red sandstone. From drift in same creek-bed.

No. 100 (H). Mica schist from Oak rapids, half a mile below Seller's camp.

No. 101 (H). Granite, interbedded with mica schist at same place.

No. 102 (H). Mica schist containing numerous garnets. From foot of Oak rapids.

No. 103 (H). Drift conglomerate, Rapid No. 30, west line of sec. 7, 65-24.

No. 104 (H). Mica schist, interbedded with gneiss and containing more or less hornblende. From Rapid No. 31, just below the place where the river leaves Twp. 65-24.

No. 105 (H). Syenite or dioryte, hard, massive and not at all jointed. From the next point below Rapid No. 31.

No. 106 (H). Doleryte, from dyke just above Rapid No. 37.

No. 107 (H). Mica schist, cut by gneiss. Rapid No. 39.

No. 107A (H). Same gneiss containing garnets, beryl (?) and tourmaline

No. 107B (H). Tourmaline; same locality.

No. 108 (H). Samples of inclusions in 107 (H) composed of biotite and augite (?)

No. 109 (H). Boulder clay. From west bank of river about four miles and a half below Rapid No. 39.

No. 110 (H). Black gravel and sand. From northeast side of river about four and a half miles below Rapid No. 40. (*Onakaiamis bachtik*).

RAINY LAKE RIVER.

No. 111 (H). Pyritous, chloritic mica schist. From a small island in the river three miles and a half below Fort Francis.

No. 112 (H). Mica schist. Same place as last.

No. 113 (H). Green hydromica schist, British side of river, a mile and a half below Fort Francis.

No. 114 (H). Siliceous schist containing mica more or less hydrated. Same locality as last.

No. 115 (H). Dyke rock with superinduced schistosity. Same place.

No. 116 (H). Quartzose beds in mica schist. A short distance up the river from last.

Nos. 117 (H), 117A (H), 117B (H), 117C (H) and 117D (H) illustrate a gradual transition from massive porphyry to mica schist. From a small island in the river about a mile below Fort Francis.

No. 117E (H) shows an abrupt contact between the two.

No. 117F (H). A porphyritic nodule or inclusion in the mica schist. Same locality.

Nos. 118 (H) and 118A (H). Specimens of rock similar in appearance and from contiguous strata; one containing mica, the other hornblende. From a small island just east of the last.

No. 119 (H). Showing contact between the schist inclusions and the porphyry which contains them. Same locality.

No. 120 (H). Porphyritic schist containing both mica and hornblende. Same locality.

No. 121 (H). Greenstone having the appearance of trap, from the west end of a dyke (?) on the American bank a short distance above last locality.

No. 121A (H). A specimen from the same dyke (?) ten feet farther east, having a schistose structure.

No. 122 (H). Doleryte (?). From a dyke a little farther up stream than the last.

No. 122A (H). Specimen from the same dyke resembling the porphyry which it cuts.

No. 123 (H). Porphyry containing chlorite and pink feldspar. Near last.

No. 124 (H). Mica schist grading into diabase. Same locality.

No. 125 (H). Porphyritic gneiss. From the falls at Fort Francis.

No. 126 (H). Porphyritic syenite, containing red and green feldspar. N. W. ¼ sec. 35, 71-24.

No. 127 (H). Fine, jointed mica schist. Canadian side of the river at the Indian agency.

RAINY LAKE.

No. 128 (H). Mica schist and siliceous schist in fine beds, twisted and folded together. East side of point in N. W. ¼ sec. 29, 71–23.

No. 129 (H). Semi-crystalline rock in dyke-like beds, generally, but not always, conformable to the schist. From N. E. ¼ sec. 29, 71–23.

No. 130 (H). Mica schist, containing veins of quartz stained very dark red. N. W. ¼ sec. 28, 71–23.

No. 131 (H). Felsitic mica schist. Same locality.

No. 132 (H). Fine, hard, green mica schist. Center of sec. 28, 71–23

No. 133 (H). Mica schist, with long, slender crystals of hornblende on the surface. Same locality.

No. 134 (H). Trap rock. From a dyke in N. E. ¼ sec. 28, 71-23.

No. 134A (H). Same rock, with crystals of epidote (?) on weathered surface.

No. 135 (H). Soft, ferruginous schist in mica schist. A little east of last.

No. 136 (H). Hard, micaceous, hornblende schist. A little east of last.

No. 137 (H). Heavy, black mineral, occurring in veins in the rock at last locality.

No. 138 (H). Dyke rock from a small dyke just east of last.

No. 139 (H). Variegated schist, containing much quartz and feldspar and a green mineral.

No. 140 (H). Fine, thin-bedded mica schist. N. E. ¼ sec. 28, 71–23.

No. 141 (H). Hydromica schist. East of last.

No. 142 (H). Gneiss cutting mica schist. South end of island in N. E. ¼ sec. 28, 71-23.

No. 143 (H). Granulyte veins cutting 142 (H).

No. 143A (H). Mica schist in small beds enclosed in 142 (H) and 143 (H).

No. 144 (H). Mica schist in irregular masses enclosed in 142 (H).

Nos. 145 (H), 145A (H), 145B (H), 145C (H), 145D (H), 145E (H) and 145F (H) show the change in the character of a dyke from the edge toward the middle. N. E. ¼ N. E. ¼ sec 27, 71-23.

No. 146 (H). Epidote found in connection with the same dyke farther southeast.

No. 147 (H). Sample from same dyke from an island south of the point in N. W. ¼ sec. 26, 71-23.

No. 148. (H). Coarse dark schist contained in the dyke in S. E. ¼ sec. 26, 71-23.

Nos. 149 (H) and 149A (H) are samples showing a schistose aspect of this dyke-rock.

No. 150 (H). Heavy, black mineral from mica schist in S. E. ¼ S. W. ¼ sec. 25, 71-23.

No. 151 (H). Siliceous mica schist from S. E. ¼ S. E. ¼ sec. 25, 71-23.

No. 152 (H). Conglomeritic mica schist. S. W. ¼ sec. 30, 71-22.

No. 153 (H). Soft, fine, green mica schist. Same locality.

No. 154 (H). Pebbles from conglomeritic schist, east of last, in sec. 30, 71-22.

No. 155 (H). Gneissic mica schist: Same place as last.

Nos. 156 (H), 156A (H) and 156B (H) show a change from mica schist to fine granulyte.

No. 157 (H). Hydromica schist. From an island in N. E. ¼ sec. 32, 71-22.

No. 158 (H). Gneiss. N. E. ¼ N. W. ¼ sec. 10, 70-22.

No. 159 (H). Soft and crumbling mica schist. From "Black bay," S. W. ¼ sec. 13, 70-22.

KABETOGAMAK.

No. 160 (H). Mica schist with the biotite in circular aggregations and spots. N. E. ¼ N. W. ¼ section 30, 70-21.

No. 161 (H). Coarse muscovite gneiss interbedded with mica schist. From the small island in S. W. ¼ S. E. ¼ sec. 30, 70-21.

No. 162 (H). Graphic granite. N. E. ¼ N. W. ¼ sec. 6, 69-21.

No. 163 (H). Coarse gneiss. Same locality, contains scales which are half biotite and half muscovite.

No. 164 (H). Porphyritic, biotite gneiss. S. W. ¼ sec. 25, 69-21.

No. 165 (H). Mica. Sec. 31, 70-21.

No. 166 (H). Gneiss, containing much biotite. North side of lake in T. 69-20.

NAMEKAN LAKE.

No. 167 (H). Gneiss. S. W. ¼ S. W. ¼ sec. 28, 69-19.

No. 168 (H). Gneiss, containing much muscovite. N. W. ¼ S. E. ¼ sec. 30, 69-18.

No. 169 (H). Gneiss. S. W. ¼ sec. 26, 69-18.

No. 170 (H). Dioryte. S. E. ¼ N. W. ¼ sec. 29, 69-17.

No. 171 (H). Gneiss. S. E. ¼ N. W. ¼ sec. 21, 69-18.

No. 172 (H). Garnetiferous gneiss. Foot of Kettle falls.

RAINY LAKE.

No. 173 (H). Hard, fine, brittle mica schist. The rock at the American or North Kettle fall.

No. 174 (H). Coarse gneiss, garnetiferous. Same locality.

No. 174A (H). Mica from 174 (H).

No. 175 (H). Hydromica schist. Same locality.

No. 176 (H). Gneiss containing green muscovite. From the point near the centre of S. W. ¼ sec. 27, 70-18.

No. 177 (H). Nodule of hard mica schist Same locality.

No. 178 (H). Conglomeritic boulder of mica schist. S. E. ¼ S. W. ¼ sec. 21, 70-18.

No. 179 (H). Porphyritic, coarse gneiss. Just north of last.

No. 180 (H). Coarse gneiss. N. W. ¼ S. W. ¼ sec. 21, 70-18.

No. 180A (H). Pegmatyte. From last.

No. 181 (H). Red mica schist. Same locality.

No. 182 (H). Gneiss from an intrusion. Same locality.

No. 183 (H). Garnetiferous gneiss. Same place.

No. 184. (H). Coarse, garnetiferous gneiss. From a small island in S. E. ¼ S. W. ¼ sec. 21, 70-18.

No. 184A (H). Radiated masses of quartz and mica in fine grains and scales (greisen ?). Same locality.

No. 184B (H). Muscovite from 184 (H).

No. 185 (H). Mica schist lying on east side of 184 (H).

No. 186 (H). Gneiss. S. E. ¼ sec. 20, 70-18.

No. 187 (H). Graphic granite. S. W. ¼ S. W. ¼ sec. 19, 70-18.

No. 188 (H). Same as 184A (H). From the point on the south line of S. E. ¼ sec. 23, 70–19.

No. 189 (H). Garnetiferous gneiss containing green muscovite and in contact with mica schist, N. W. ¼ S. W. ¼ sec. 23, 70–19.

No. 189A (H). Same as 184A (H). Same locality as last.

No. 190 (H). Pebbles from a recess in the shore, S. W. ¼ N. W. ¼ sec. 21, 70–19.

No. 191 (H). Mica schist. N. W. ¼ sec. 20, 70–19.

No. 192 (H). Chloritic mica schist. S. E. ¼ sec. 19, 70–19.

No. 192A (H). Hornblendic rock from veins in last.

No. 193 (H). Horizontally stratified mica schist. N. E. ¼ N. W. ¼ sec. 15, 70–20.

No. 194 (H). Mica schist. S. E. ¼ S. W. ¼ sec. 10, 70–20.

No 194A (H). Garnetiferous mica schist. Same locality.

No. 195 (H). Gneiss. S. W. ¼ S. W. ¼ sec. 9, 70–20.

No. 196 (H). Average specimen of mica schist from N. W. ¼ S. W. ¼ sec. 8, 70–20

No. 197 (H). Hard mica schist. S. ½ sec. 7, 70–20.

No. 197A (H). Quartz vein in last.

No. 198 (H). Coarse gneiss containing green mica. N. E. ¼ N. E. ¼ sec. 12, 70–21.

No. 198A (H). Fine gneiss. Same place.

No. 199 (H). Cyanite. N. E. ¼ N. W. ¼ sec. 12, 70-21.

No. 200 (H). Garnetiferous mica schist. S E. ¼ S. W. ¼ sec. 1, 70–21.

No. 201 (H). Mica schist. S. E. ¼ N. W. ¼ sec. 33, 71–20.

No. 202 (H). Mica schist with the biotite in spots. N. E. ¼ sec. 32, 71–20.

No. 203 (H). Hard, thick-bedded mica schist S. W. ¼ sec. 29, 71-20.

No. 204 (H). Hydromica schist. N. W. ¼ S. W. ¼ sec 29, 71–20.

No. 205 (H). Siliceous mica schist. S. W. ¼ S. E. ¼ sec. 26, 71–21.

Nos. 206 (H), 206A (H), 206B (H), 206C (H), 206D (H) and 206E (H) represent a transition from mica schist to amphibolyte. S. E. ¼ N. W. ¼ sec. 35, 71-21.

No. 206F (H). Same as 206E (H), (amphibolyte) containing much quartz in veins.

No. 207 (H). Hydromica schist, garnetiferous. S. W. ¼ N. W. ¼ sec. 14, 71-21.

No. 208 (H). Light-colored, siliceous mica schist. S. W. ¼ N. W. ¼ sec. 33, 71-21.

No. 209 (H). Felsitic schist. N. W. ¼ N. E. ¼ sec. 32, 71-21.

No. 210 (H). Mica schist. S. E. ¼ N. W. ¼ sec. 32, 71–21.

No. 211 (H). Greenstone. N. E. ¼ N. W. ¼ sec. 31, 71–21.

No. 212 (H). Mica schist. N. E. ¼ N. W. ¼ sec. 31, 71–21.

No. 212A (H). Schist just north of last.

No. 212B (H). Light-colored schist on both sides of 212 (H).

No. 213 (H). Hydromica schist. S. E. ¼ S. E. ¼ sec. 24, 71–22.

No. 214 (H.) Light-colored, siliceous schist. On an island in S. E. ¼ S. E. ¼ sec. 28, 71–22.

No. 215 (H). Siliceous schist. South side of the island in N. E. ¼ S. W. ¼ sec. 28, 71-22.

No. 216 (H). Hydromica schist and graywacke. On the east end of the island in S. E. ¼ sec. 19, 71-22.

No. 217 (H). Diabasic schist. N. E. ¼ S. E. ¼ sec. 19, 71-22.

No. 218 (H). Hydromica schist. South side of an island about a quarter of a mile west of last.

No. 219 (H). Light-colored, feldspathic mica schist stained with iron rust. S. E. ¼ S. W. ¼ sec. 24, 71-23.

No. 221 (H). Doleryte containing much magnetite. On the point in S. E. ¼ S. E. ¼ sec. 23, 71-23.

No. 222 (H). Hardened mica schist lying on east side of last.

No. 223 (H). Hard, green schist lying between mica schist on the south and hydromica schist on the north. S. W. ¼ S. W. ¼, sec. 23, 71-22.

BIG FORK RIVER.

No. 224 (H). Clay containing fresh water shells. From banks fifteen feet high, about seven miles up the river.

No. 225 (H). Mica schist containing large garnets. From drift at same place.

No. 226 (H). Greenstone. East bank of river, about thirty-three miles above Rainy Lake river.

No 227 (H). Mica schist and gneiss. Just below the "Big falls," about forty-one miles up the river.

No. 227A (H). Dyke rock cutting No. 227 (H).

No. 228 (H). Trap. From dyke at head of "Big falls."

No. 229 (H). Gneiss and mica schist from immediate contact with the dyke.

No. 230 (H). Samples of the gneiss and schist which underlie the principal part of the falls. (The last four numbers are from sec. 36 or sec. 35, 155-25).

No. 231 (H). Gneiss. In the river, about a mile above the falls.

No. 232 (H). Limestone pebbles and Cretaceous shale from a clay bank about sixty-three miles up the river, near sec. 1, 152-25.

No 233 (H). Fine mica schist. About seventy-seven miles above the mouth.

No. 234 (H). Trap from dyke a little above last.

No. 235 (H). Schist from edge of the same dyke.

No. 236 (H). Dyke-rock, light colored and having the composition of granite. Same locality.

No. 237 (H). Schist; fine, micaceous. Same place.

No. 238 (H). Fine, green, diabasic schist, about eighty-thr above the mouth of the river at the head of a rapid.

No. 239 (H). Dyke-rock. From the "Little falls"; about five and one-half miles up the river.

No. 239A (H). Samples of green veins seen in the dyke.

No. 239B (H). Specimen from dyke showing apparent sch

No. 239C (H). "Slickensides" from same dyke.

No. 239D (H). From a vein of quartz and calcite in the d

No. 240 (H). Diabase, about forty rods above the falls.

No. 241 (H). Cretaceous (?) clay. About ninety-three the Big Fork at the foot of a rapid.

No. 242 (H). Syenite from a large boulder. Same place.

No. 243 (H). Green schist containing a little mica. At on Deer river, about half a mile from the Big Fork.

No. 244 (H). Porphyritic greenstone. About three mil the mouth of Deer river, one hundred and four miles above t of the Big Fork.

No. 244A (H). Same as 244 (H): but containing pyrites.

No. 245 (H). Hard, jointed, green rock similar to 244 (H) two and one-half miles farther up stream, contains calcite.

Nos. 246 (H), 246A (H) and 246B (H) are specimens of di different grades of coarseness. About a mile above last.

No. 247 (H). Feldspathic greenstone. Foot of Rice Riv about one hundred and eleven miles above Rainy Lake river.

No. 247A (H). A felsitic variety of the same rock.

Nos. 248 (H), 248A (H) and 248B (H) illustrate the cha greenstone schist to dioryte or syenite. 248B (H) is very hor

No. 249 (H). Feldspathic greenstone. A little south of l

No. 250 (H). Quartz dioryte. About 120 miles up the at the west side of sec. 30, 61–26.

No. 250A (H). Rock similar to 250 (H). From east side 61–27.

No. 251 (H). Chloritic, porphyritic granulyte. About f above the last.

No. 252 (H). Siliceous dioryte (?). About three miles al

No. 252A (H). Quartz crystals from a geode in 252 (H).

No. 253 (H). Syenite. In the woods 24 rods east of 252 (

No. 254 (H). Syenite. From the next bend in the riv 253 (H).

No. 255 (H). Limestone fragments from the bed of the creek leading into lake Winibigoshish in T. 147-27.

MISSISSIPPI RIVER.

No. 256 (H). Quartzyte. N. E. ¼ N. W. ¼ sec. 13, 55-26.

No. 257 (H). Nodules of sesquioxide of iron. From the quartzyte at Pokegama falls.

No. 258 (H). Quartzyte showing decomposition and bedding structure. Pokegama falls.

No. 259 (H). Quartzyte containing catlinite (?). Same locality.

PRAIRIE RIVER.

No. 260 (H). Ferruginous quartzyte. Foot of "Lower falls" of Prairie river.

No. 260 A (H). Hematite. Same place.

No. 261 (H). Quartzyte. Lower part of Lower fall.

No. 262 (H). Fine conglomerate. About two-thirds of the way from the foot to the head of the Lower fall.

No. 263 (H). Jaspery, ferruginous quartzyte containing chalcedonic quartz. Same place.

No. 264 (H). Quartzyte; showing rusty ferruginous spots. Same locality.

No. 265 (H). Quartzyte from upper end of Lower fall.

No. 266 (H). Gneiss, from a large, irregular-shaped mass, at foot of Lower fall.

No. 267 (H). Fine, gray gneiss. From foot of "Upper fall," east side sec. 33, 55-25.

No. 268 (H). Different varieties of gneiss seen in going from the foot to the head of the Upper fall.

No. 268A (H). Gypsum. Upper falls, Prairie river.

No. 269 (H). Garnetiferous granite. Same place.

No. 270 (H). Gneiss, containing red feldspar. Locality the same.

No. 271 (H). Gneiss, similar to that at the Upper fall. N. W. ¼ sec. 34, 56-25.

No. 272 (H). Micaceous syenite gneiss. Northeast of last.

No. 273 (H). Gneiss, containing veins of dark-red feldspar. Same place.

No. 274 (H). Dark, green rock, like doleryte. Locality the same.

No. 275 (H). Porphyritic, hornblendic gneiss. S. E. ¼ sec. 27, 56-25.

No. 275A (H). Coarse, red, muscovite granite; cutting last.

No. 276 (H). Hornblende schist, containing mica. Upper end of per fall.

No. 276A (H). Same as last; cut by a vein of red feldspar

No. 277 (H). Fine hornblende schist cutting the gneiss.

No. 277A (H). Showing the contact between the gneiss and No. 77 (H).

No. 278 (H). Fine hornblende gneiss. Same locality.

No. 279 (H). Fine, biotite, muscovite gneiss. S. E. ¼ N. E. ¼ sec. 5, 56–24.

No. 280 (H). Gneiss. N. W. ¼ N. W. ¼ sec. 9, 56–24.

No. 281 (H). Gneiss. S. W. ¼ sec. 33, 57–23.

No. 282 (H). Bluish-gray clay. From the bed of Sucker brook, in sec. 27, 57–24.

No. 283 (H). Coarse, jointed, chloritic gneiss. Upper end of Upper fall.

MISSISSIPPI RIVER.

No. 284 (H). Blue and red clay. From the river banks in T. 54–24.

No. 285 (H). "Silver ore," so-called. T. 61–23. (Upon analysis, this rock was found to contain no traces of either gold or silver).

HOODOO LAKE.

No. 286 (H). Gneissic mica schist. N. E. ¼ S. W. ¼ sec. 4, 63-18.

No. 286A (H). Gneiss. North side of Hoodoo lake.

No. 287 (H). Hydromica schist, very siliceous. N. E. ¼ S. E. ¼ sec. 5, 63-18.

No. 288 (H). Ferruginous hornblende schist. West of last.

No. 289 (H). Fine syenite gneiss. West of last.

No. 290 (H). Soft, red mica schist. At portage in N. W. ¼ S. ¼ sec. 5, 63-18.

SUSAN LAKE.

No. 291 (H). Fine mica schist. On a small island in sec. 64-18.

No. 292 (H). Rock composed of hornblende and biotite, wi little feldspar. Same locality.

No. 292A (H). Same as last with graphite(?).

No. 293 (H). Pink mica schist containing green mica. S. E E. ¼ sec. 32. 64-18.

No. 294 (H). Gneiss. From a small island in southeast end of the lake.

ELBOW LAKE.

No. 295 (H). Mica schist. From the bay east of the one to which the portage from Susan lake leads.

No. 296 (H). Gneiss. From same bay, north of last.

No. 297 (H). Rock similar to 292 (H). From northeast end of Elbow lake.

No. 298 (H). Chloritic gneiss. Same locality.

No. 299 (H). Fine, red syenite gneiss. From the deep bay directly north of the portage from Susan lake, on the opposite side of Elbow lake.

No. 300 (H). Fine, gray biotite gneiss. Southwest of last.

No. 301 (H). Coarse granular gneiss containing pink and white feldspar. Same locality.

No. 302 (H). Rock similar to 292 (H). From a bay on the north side of the lake near the west end.

No. 303 (H). Similar to last but containing more feldspar. From a point west of last.

No. 304 (H). Gneiss from the top of Bald Mt. North of Elbow river, in south part of T. 64-19.

No. 305 (H). Mica schist. From same place.

PELICAN LAKE.

No. 306 (H). Pink gneiss. N. E. ¼ S. W. ¼ sec. 2, 64-20.

No. 307 (H). Mica schist. Same locality.

No. 308 (H). Fine gray gneiss. From south side of point in N. E. ¼ S. W. ¼ sec. 2, 64-20.

No. 309 (H). Dyke rock from an island in N. E. ¼ S. E. ¼ sec. 3, 64-20.

No. 310 (H). Hornblendic mica schist. From an island near the centre of sec. 3, 64-20.

No. 310A (H). Heavy, dark, hornblendic rock containing round grains of feldspar that resemble amygdules. Interbedded with last.

No. 311 (H). Hornblendic porphyritic gneiss. N. E. ¼ sec. 12, 64-21.

No. 312 (H). Mica schist enclosed in gneiss. From point in N. E. ¼ N. W. ¼ sec. 12, 64-21.

No. 313 (H). Coarse, granular, white, siliceous gneiss. N. E. ¼ sec. 35, 65-20.*

No. 314 (H). Siliceous granite. Same locality.

No. 315 (H). Mica schist containing a vein of granite. From small island near S. E. ¼ sec. 26, 65-20.*

No. 316 (H). Micaceous hornblende schist. Same island.

No. 317 (H). Dark rock similar to last, but more schistose, and containing vitreous quartz grains. About a quarter of a mile northwest of last.

No. 318 (H). Gneissic mica schist. Near N. W. ¼ sec. 26, 65–20.

No. 318A (H). Mica schist, interbedded with hornblendic mica schist. Same locality.

No. 319 (H). Handsome gray gneiss. Just west of last.

No. 320 (H). Syenite. A short distance north of last.

No. 321 (H). Hornblende schist enclosed in gneiss. From the island in N. W. ¼ sec. 26, 65–20.

No. 321A (H). Samples of mica and radiations of mica scales and quartz grains (greisen?). Same island.

No. 322 (H). Siliceous mica schist containing pyrite, hornblende, malachite, chalcopyrite and a greenish-yellow mineral. Same island.

No. 323 (H). Breccia. Point near S. W. ¼ sec. 29, 65–20.

No. 324 (H). Micaceous, porphyritic syenite. From an island in N. E. ¼ sec. 31, 65–20.

No. 325 (H). Pyritous, garnetiferous, micaceous syenite gneiss. From the small island in N. W. ¼ sec. 31, 65–20.

No. 325A (H). Fine, hornblendic gneiss. Same locality.

NET LAKE.

No. 326 (H). Mica schist. From a small island near the east side of the lake, west of the Indian village.

No. 326A (H). Rock composed of feldspar, quartz and some greenish-brown mineral. Same island.

No. 327 (H). Trap, cutting 326 (H).

PELICAN LAKE.

Samples of the rock on the point in sec. 35, 65–21, and illustrated in figure No. 16 are

No. 328 (H). Mica schist.

No. 329 (H). Hornblendic inclusions.

No. 330 (H). Porphyritic gneiss.

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* All locations given in Twp. 65-20 are only approximately correct, as the township is unsurveyed.

No. 330A (H). Mica schist in contact with the gneiss.

No. 330B (H). Contact of gneiss with hornblendic inclusions.

No. 330C (H). Dyke of fine diabase cutting enclosed mica schist.

No. 330D (H). Mica schist containing "geodules" of garnets.

No. 330E (H). Sample of granite intrusion or "stringer" from the main mass.

No. 331 (H). Pegmatyte. N. E. ¼ sec. 30, 65-20.

No. 332 (H). Heavy, green rock, mostly composed of hornblende, in contact with gneiss. N. W. ¼ sec. 36, 65-20.

No. 332A (H). Same rock near its contact with mica schist.

TROUT LAKE.

No. 333 (H). Siderite. On masses of quartz at the old "stamp mill" on the stream between Trout lake and Vermilion lake.

No. 334 (H). Mica schist. In the river channel, between the two lakes.

No. 335 (H). Hornblende schist containing red feldspar. Same place.

No. 336 (H). Gneiss, more or less hornblendic. Same locality.

No. 337 (H). Showing contact between mica schist and red gneiss. Same locality.

No. 338 (H). Fine, gray, porphyritic gneiss. N. W. ¼ N. W. ¼ sec. 19, 63-15.

No. 339 (H). Gneissic schist with the mica partly hydrated. Same locality.

No. 340 (H). Syenite gneiss. North side of point at last place.

No. 341 (H). Gneiss. S. E. ¼ N. E. ¼ sec. 13, 63-16.

No. 342 (H). Granite intrusion cutting mica schist. Same locality.

No. 343 (H). Hornblendic mica schist. S. W. ¼ S. W. ¼ sec. 13, 63–16.

No. 344 (H). Mica schist. Same place.

No. 345 (H). Porphyritic syenite gneiss. S. W. ¼ S E. ¼ sec. 14, 63–16.

No. 345A (H). Nodules of amphibolyte and actinolite. Same place.

No. 346 (H). Reddish biotite gneiss, N. W. ¼ sec. 14, 63–16.

No. 347 (H). Red chlorite gneiss. S. E. ¼ S. W. ¼ sec. 15, 63–16.

No. 348 (H). Fine, pinkish granite. N. E. ¼ S. E. ¼ sec. 10, 63-16.

No. 449 (H). Muscovite in quartz. Same locality.

No. 349A (H). Coarse orthoclase. Same place.

No. 350 (H). Granite. S E. ¼ N. W. ¼ sec. 11, 63-16.

No. 351 (H). Porphyritic syenite. N. E. ¼ N. W. ¼ sec. 11, 63–16.

No. 352 (H). Hornblendic gneiss. N. E. ¼ sec. 11, 63–26.

No. 353 (H). Fine, gray, biotite gneiss containing plagioclase. S. E. ¼ N. E. ¼ sec. 11, 63–16.

NOTES

ON

MOLLUSCAN FAUNA OF MINNESOTA

ULY. S. GRANT.

NOTES ON THE MOLLUSCAN FAUNA OF MINNESOTA.

BY ULY. S. GRANT.

Since the publication, in the Fourteenth (1885) Annual Report, of a list of the mollusca in the University museum, a few species and a larger number of specimens have been collected. These specimens are mostly from the three north-eastern counties of the state, St. Louis, Lake and Cook, and were collected by the writer during the last two summers, while with a party of the Geological Survey. The lack of good transporting accommodations and press of other duties prevented a very careful and thorough search being made, and as yet not more than half of the material so collected has been examined and classified. The following very incomplete list is published with the hope that it will throw a small degree of light on the fauna of a part of the state yet unexplored. The writer soon hopes to make the list more complete; probably twice as many species have been found in that region as are here given. The lakes of the country passed over contained only one species of *Unio*, i. e., *Unio luteolus*, Lamarck, and one or two of *Anodonta*. The Gasteropoda are represented by a very limited number of species, and by far less individuals than are found in the central or southern portion of the state. The water forms are not abundant, but where found are of rather larger size than the same species found elsewhere. The land forms are small, thick shelled, and possess the characteristics of a northern fauna.

So far the survey has not received many shells from different parts of the state, but it is hoped that this will not long be the case. Prof. John M. Holzinger, of the Winona Normal school has kindly contributed a good number of specimens from that county, and has also sent the subjoined list of Winona county mollusca.

The localities given below are additional to those given in the former list; and the species marked (*) are not found in that list.

LIMACIDÆ.

Zonites nitidus*, Müller.—Rather common in damp woods near Minneapolis, easily confused with *Z. arboreus*, Say, but ***nitidus* is a larger shell, and the last whorl is disproportionately large. 2101.[1]

**Zonites indentatus*, Say.—Winona county. Only three specimens are in the museum, and these are rather below the average size. 1894.

**Zonites fulvus*, Draparnaud.—Tower, St. Louis county, and Minneapolis; quite common; a very pretty small shining brown shell. 1950, 2093.

**Vitrina limpida*, Gould.—Tower, St. Louis county. Two specimens were found, but after long and careful search no more could be discovered. This is a very fragile, transparent shell, with the last whorl proportionately very large. 1951.

HELICIDÆ.

Patula alternata, Say.—Winona and Tower. Only three specimens were found at the latter place, and they were much below the average size. The shells from Winona are subcarinate and quite small. 1897, 1952.

Patula striatella, Anthony.—Winona and Tower. Quite common at Tower, where this shell has very prominent ribs. 1886, 1953.

Helicodiscus lineatus, Say.—Traverse county, Tower, Winona. Some of the specimens in the museum have three distinct pairs of teeth. 1895, 1954, 2098.

Strobila labyrinthica, Say.—Tower and Winona. This shell has three parallel revolving laminæ on the inner wall. The specimens from Tower are much smaller than those from other localities. 1893, 2055

Stenotrema hirsutum, Say.—Winona. 1870.

Stenotrema monodon, Rackett.—Winona and Minneapolis. The specimens found at the latter place are large and strong. 2102.

Mesodon albolabris*, Say.—Winona. This species sometimes has a small parietal tooth, and then it is easily confounded with ***M. exoletus*, Binney, but the latter shell is not found in Minnesota. 1905.

Mesodon multilineata, Say.—Winona. The specimens from this locality are much smaller than those found at Minneapolis. 1983.

**Mesodon profundus*, Say.—Winona. This species is often found crawling along the trunks of trees. Individuals without the revolving band are common. 1904.

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[1] These numbers refer to the Zoological Register of the University museum.

* *Acanthuinla harpa*, Say.—Tower. This species is thought to be ircumpolar; it is a very small umbilicated shell with heavy ribs on he last two whorls. 1956.

Vallonia pulchella, Müller.—Tower, Winona and Big Stone county. 896, 1897, 2096.

PUPIDÆ.

**Pupa fallax*, Say.—Winona. 1890.

STENOGYRIDÆ.

Ferussacia subcylindrica, Linnæus. Tower and Winona. Rather re at Tower. 1889, 1959.

AURICULIDÆ.

Carychium exiguum, Say.—Tower. Rather common in the moss in marack swamps. 1964.

LIMNÆIDÆ.

Limnæa stagnalis, Linnæus.—Winona, Tower and Lake county. ot very common in the northeastern part of the state, but when und there the shell is usually quite fragile and of large size. 1880, 65, 2020.

Bulimnea megasoma, Say. Vermilion lake and other lakes in St. uis and Lake counties. Rather rare, only a few specimens being und in the same locality. The animal is quite sluggish in its movents, and is found clinging to aquatic plants in still water around e mouths of streams. 1966, 2021, 2022.

**Limnophysa emarginata*, Say.—Found along the boundary waters Lake county. The specimens collected vary much in size; on a w the corrugations of the body whorl near the aperture are very stinct. 1970.

**Acella gracilis*, Jay.—Vermilion lake. But one specimen was und, and this is only a little over half an inch long, but the length about six times the diameter; this is by far the most slender and ragile of our Limnæidæ, and is quite rare. 1976.

Physa gyrina, Say.—Common in Vermilion lake. 2026.

Bulinus hypnorum, Linnæus.—A few specimens were found in a wamp near Tower, but these are only about one half the size of hose found at Minneapolis, and the epidermis is rougher and less rilliant. 1982.

**Planorbella campanulata*, Say. — Wright county, Winona, and Cook, Lake and St. Louis counties. This is the most common shell of the northern lakes of Minnesota; it varies from two-eighths to five-eighths of an inch in diameter, according to locality. 1875, 1876, 1983–6.

Helisoma corpulenta, Say.—Vermilion lake and all over St. Louis and Lake counties. This shell seems to be quite distinct from *H. trivolvis*, Say; it is much heavier and much higher in proportion to its diameter, and is also distinctly carinated,—always on one side and frequently on both,—and the aperture is much higher than the penultimate whorl. It is found clinging to rocky shores and reefs, and seems to seek places where the water is quite rough. 1988, 2029.

Helisoma bicarinata, Say.—Vermilion lake, Winona, Lake county, and various places in St. Louis county. This shell varies greatly in size, and is always found associated with *Planorbella campanulata*, Say, which, however, is the more common. 1878, 1991–4.

**Menetus exacutus*, Say.—A few specimens were found in Vermilion lake; one has the body whorl deflected for the last half of its length. 1995, 1996.

Gyraulus deflectus, Say.—Very common in all of the lakes of St. Louis, Lake and Cook counties,—in fact, it is the only shell that can be said to be at all abundant in that part of the state; it is found in large numbers clinging to the rocky shores of the lakes.

**Segmentina armigera*, Say.—Rather common on the shores of a small island in Vermilion lake. It is a solid little shell and is easily recognized by the five teeth far within the mouth. The specimens collected are less than a fourth of an inch in diameter. One or two of the teeth may be sometimes lacking, and rarely all of them are. 1987.

VALVATIDÆ.

Valvata tricarinata, Say.—Wright, Lake and St. Louis counties. The specimens from Wright county are quite large, while those from St. Louis county are much smaller and rarer. 1593, 2005, 2006.

VIVIPARIDÆ.

Vivipara intertexta, Say.—Winona, 1901.

NOTES ON THE MOLLUSCA OF WINONA COUNTY.

By John M. Holzinger.

uch of the material which is the basis of these notes has been cted the last two years by the zoology classes of the Winona mal School. The students were encouraged in thus combining work and observation with text-book work, with the conviction he part of the teacher that this plan is more likely to result in ctive love of the things of nature. A number of the students sent in from several counties collections of mollusca, thus aiding modest way in the determination of geographical distribution. the shells noted are in the Winona Normal School museum. It ld be stated that Dr. J. Lindahl of Rock Island, Ill., and Mr. Marsh of Aledo, Ill., have aided in determining most of the onidæ.

LAMELLIBRANCHIATA.

UNIONIDÆ.

nodonta corpulenta, Cooper.—Four specimens from Straight slough, to five miles above Winona.* The largest specimen is 6½ inches , and 4⅜ in. high. This shell is difficult to preserve, breaking up ying Nacre reddish.

nodonta imbecillis, Say.—Three specimens found; 1 in. high, 2 in. . Color outside, greenish; inside, lighter; frail.

argaritana complanata, Barnes.—Five specimens secured. Larg- 5¼ in. long, 4⅜ in. high.

argaritana marginata, Say.—Only three specimens were found; est: 4 in. long, 2⅜ in. high, 2⅛ in. wide,—probably a female; llest: 1 in. long, ⅝ in. high.

nio æsopus, Green.—Five specimens found; largest: 4 in. long, 3 igh.

the bivalves here noted are from Straight slough, unless otherwise stated.

Unio alatus, Say.—Six specimens found; 4½ in. long, 3½ in. high.

Unio anodontoides, Lea.—Six specimens found; largest: 3 in. long, 1⅜ in. high; smallest: 1¾ in long, ⅞ in. high.

Unio asperrimus, Lea.—Seven specimens found. A pretty and firm shell, easily confounded with *U. metanever*, Raf.; in fact, I fail to see any material difference between these two shells, except that the latter has the lower posterior lobe of the shell a trifle longer; color of the epidermis the same in both shells.

Unio capax, Green.—Twelve specimens found; largest: 5 in. long, 4 in. high, 3 in. wide. Epidermis yellowish brown with rays on the young, which disappear in old shells. Nacre white. This shell has much the form of *U. occidens*, Lea, but is wider, as its name implies, and also firmer. Another closely related shell is *U. subovatus*, Lea; I can distinguish the latter from *U. capax*, only by the nacre,—*subovatus* having the posterior half of the inside covered with a beautiful peach-blow colored nacre.

Unio coccineus, Hild.—Two specimens were brought in by Miss Lewena Gallup, from near St. Charles, Winona county. Largest: 1¼ in. long, 1⅛ in. high.

Unio cornutus, Barnes.—Four specimens found; largest: 2½ in. long, 2 in. high. This shell in firmness of build and general outline stands near *asperrimus* and *metanever*.

Unio crassidens, Lam.—One specimen found, 3¾ in. long, 2⅜ in. high. This shell is of the same form and has the same nacre as *U. nigrinus*, Lea, but it is a more solid shell. It resembles a shortened *U. gibbosus*, the nacre being the same in both.

Unio ebenus, Lea.—Thirty or more specimens were collected, ranging from the smallest, hardly an inch long, to the largest: 3⅛ in. long, 3 in. wide. This shell, as to firmness, average size and general outline, reminds one of *U. ellipsis*, Lea, and *U. trigonus*, Lea. Two shells of the lot are apparently hybrids,—one, *ebenus* x *ellipsis*, the other, *ebenus* x *trigonus*,—showing the affinity between these three so-called species.

Unio elegans, Lea.—Eight specimens found. The pretty marking, of especially the younger shells, justifies the specific name *elegans*. Largest: 1¾ in. long. 1½ in. high.

Unio ellipsis, Lea.—About twenty-five specimens were collected; a number of these are quite small—less than an inch long; the epidermis of these is handsomely marked with rays, which become obscure with age. Largest: 3⅛ in. long, 2½ in. high. See *U. ebenus* above.

Unio gibbosus, Barnes.—Five specimens collected; largest: 4⅛ in. long, 1⅝ in. wide. In firmness and nacre like *U. crassidens*,—in fact one shell collected stands between these two species in relative length and hight;

crassidens 3¾x2⅜;
gibbosus 4⅛x1⅝;
hybrid 3x1½:

Epidermis, nacre and build are the same in the three shells.

Unio gracilis, Barnes.—Six specimens collected; largest: 3½ in. long, 2½ in. high. I fail to see the slightest difference between this species and *U. lævissimus*, Lea.

Unio lævissimus, Lea.—One specimen.

Unio ligamentinus, Lam.—Three large shells were collected, one with white nacre, the other with peach-blow inside. Largest: 5 in. long, 3¼ in. high. Obscure rays on epidermis.

Unio luteolus, Lam.—Some fifteen specimens were collected. Those of middle size, 2½x1½ in., I have difficulty in distinguishing from *U radiatus*, Lam.; the epidermis at that age is yellowish or light green crossed by a number of dark bluish rays. Largest: 4½ in. long, 2½ in. high.

Unio metanever, Raf.—Eight shells collected; largest: 3⅛ in. long, 2¾ in. high. See *U. asperrimus*.

Unio occidens, Lea.—Six specimens collected; largest: 4x3 in. See *U. capax*.

Unio parvus, Barnes.—Seven specimens collected; largest: 1⅜ in. long.

Unio plicatus, Le Sueur.—The most common and abundant species; over 75 specimens were collected, including some less than an inch long and the largest, 5 in. long, 3½. high.

Unio pressus, Lea.—One specimen was found, 1⅛ in. long, 1 in. high.

Unio pustulosus, Lea.—Sixteen specimens were collected; largest: 2⅛ in. long, 2⅛ in. high. One specimen with fewer warts or postules seems to be *pustulosus* x *trigonus*.

Unio radiatus, Lam.—One specimen from Mr. Manuel, Odessa, Big Stone Co., Minn.

Unio rectus, Lam.—Five specimens were collected; nacre lighter colored than in *U. gibbosus*; largest shell; 6⅛ in. long, 2½ in. high.

Unio securis, Lea.—Two specimens found; largest: 3¾ in. long, 3 in. high.

Unio subovatus, Lea —Three specimens found; 3½ in. long, 2¼ in. high. See *U capax* and *occidens.*

Unio trigonus, Lea.—Quite common; over 50 specimens were collected, ranging from the quite young, 1½ in. long, to the largest, 2¾ in. long, 2½ in. high. A firm shell. The animal is frequently of a saffron color.

Unio tuberculatus, Barnes.—Five were collected; largest: 5¼ in. long. 2¾ in. high.

Unio undulatus, Barnes.—One specimen was found near St. Charles, Winona county, by Miss L. Gallup. This is 1¼ in. long, 1 in. high.

Unio zigzag, Lea.—Two specimens were found; the larger is 1½ in. long, ⅞ in. high.

CORBICULADÆ.

Sphærium transversum, Say.—A few dead shells were found in the river bottom.

Sphærium striatinum, Lam.—Was found in abundance in the same situations as *S. transversum* Miss Lillian Miller brought dead shells of this species from Goodhue county.

Sphærium rhomboideum, Say.—Occurs in lake Winona in abundance. The largest of these bivalves are ½ in. long. Young ones measuring over ⅛ in in length have been taken out of the females; these are more compressed than the adults and might be mistaken for another species, resembling more the *S. occidentale.*

Sphærium solidulum, Prime.—One was taken in lake Winona; length ⅝ in., hight $\frac{7}{16}$ in. A number of dead shells were brought from Goodhue county by Miss Lillian Miller.

Sphærium partumeium, Say.—In lake Winona.

Sphærium fabale, Prime.—None have been found near Winona, but Miss Lewena Gallup brought in ten fresh specimens from near St. Charles, Winona county.

Pisidium compressum, Prime.—These minute bivalves were found creeping over the muddy creek bottom near Laird's flouring mill. About thirty specimens were collected.

Pisidium abditum, Hald.—This bivalve, a trifle larger than the preceding, was found in lake Winona, in muddy places, crawling over submerged weeds Twelve specimens were collected.

Pisidium variabile, Prime, and

Pisidium rotundatum, Prime, have both been found recently in lake Winona, with *P. abditum*, Hald, and have been determined by Mr. Marsh, Aledo, Ill.

GASTEROPODA.

LIMACIDÆ.

Limax campestris, Binney.—Common in moist meadows.

Zonites nitidus, Müller.—After the spring flood of 1888, eight specimens were picked up alive along the shore of lake Winona, under bark that had been washed ashore; identically the same shells were found near Madison, Wis., the year before, and determined by Mr. W. Marsh.

Zonites arboreus, Say.—Abundant. This species was found alive under logs and boards, south of lake Winona.

Zonites viridulus, Menke.—Some ten specimens were collected near Stockton, Winona county. Shell more translucent than that of *Z. arboreus*; slightly smaller; outer whorl relatively larger.

Zonites minusculus, Binney.—A few dead shells were found in the meadow south of lake Winona. Determined by Dr. Sterki.

Zonites fulvus, Drap.—Only about twelve specimens have been found, half of them alive. To the naked eye this shell has much the shape and color of *Strobila labyrinthica*, Say; but under the lens the external striæ and internal laminæ of *Strobila* are absent.

HELICIDÆ.

Patula striatella, Anth.—This species was found with *Zonites arboreus*, and rather more abundant.

Helicodiscus lineatus, Say.—Dead shells of this species are found in abundance on the bluffs under stones; comparatively few live specimens have been found.

Strobila labyrinthica, Say.—Abundant in a moist meadow south of lake Winona; often found gregarious.

Stenotrema hirsutum, Say.—Some thirty specimens, mostly alive, were collected near Stockton and Winona.

Stenotrema monodon, Rack.—Only four specimens were found near Stockton, Winona county.

Mesodon albolabris, Say.—A few live shells have so far been found on the bluffs; dead shells are common.

Mesodon multilineatus, Say.—Abundant in the meadows with *Strobila labyrinthica*. It is a small variety.

Mesodon clausus, Say.—Two specimens were brought in by Miss S. Buck from bluffs south of lake Winona.

Mesodon profundus, Say.—On the bluffs; slightly more abundant than *M. albolabris.*

Vallonia pulchella, Müller.—Under logs and stones on the bluffs; more shells are found dead than alive.

PUPIDÆ.

Pupa pentodon, Say.—Occurs in a wet meadow.

Pupa fallax, Say.—In moist meadows; rare.

Pupa armifera, Say.—Our largest species of *Pupa;* common along the bluffs and in moist meadows.

Pupa contracta, Say.—Rather rare.

Pupa corticaria, Say.—Under stones on the bluffs.

SUCCINIDÆ.

Succinea ovalis, Gld.—Abundant on rushes along the Mississippi. Two sets, one collected in June, the other in September, showed an increase, in the latter set, to nearly double the size in June.

Succinea avara, Say.—Along the Mississippi. Rare.

Succinea obliqua, Say.—A few specimens from Root river, south, brought by Miss Laura Wright, are evidently of this species.

AURICULIDÆ

Carychium exiguum, Say.—Found in goodly numbers in wet places south of lake Winona, under chips and boards in water.

LIMNÆIDÆ.

Limnæa ?stagnalis, Linn.—A few specimens were found in lake Winona. Abundant in the fall of 1888.

Limnæa palustris, Müller. — In abundance in pools along lake Winona.

Limnæa humilis, Say.—On muddy flats in the Mississippi; especially in Straight slough.

Probably one or two more species of Limnæa may be found in the collected material, some of which is not yet worked up.

Physa ancillaria, Say.

Physa heterostropha, Say.

Physa wolfiana, Say.

Physa elliptica, Lea.—All these species of Physa, and probably several more, have been collected in the springs and brooks in this county. I take the species commonly found on watercress to be *P. elliptica*, Lea.

Planorbis campanulatus, Say.—Common. This and the following species of *Planorbis* have been collected in lake Winona.

Planorbis trivolvis, Say.—Common.

Planorbis bicarinatus, Say.—Abundant.

Planorbis exacutus, Say.—Rather rare.

Planorbis deflectus, Say.—Common.

Planorbis parvus, Say.—Rare.

Segmentina armigera, Say.—Quite common.

VALVATIDÆ.

Valvata sincera, Say.—Lake Winona. Not common.

VIVIPARIDÆ.

Vivipara intertexta, Say.—In Mississippi river. Rare.

Melantho subsolida, Say.—In abundance in the Mississippi river.

RISSOIDÆ.

Somatogyrus subglobosus, Say.—In Mississippi river.

Amnicola limosa, Say. In lake Winona. Not very common.

HELICINIDÆ.

Helicina occulta, Say.—Dead shells have been found for two years, but in the cold, wet spring of 1888 about a dozen live shells of this pecies were found, some near Stockton and some near Winona.

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Corrections and additions for the report for 1886.

Page 27. Second line from bottom, for "62-15" read "62-14."

Page 37. Halt 69. For "sec. 25" read "sec. 35."

Page 39. After Halt 75, add:

HALT 76. N. W. ¼ S. W. ¼ sec. 32, T. 63-13. Base of point, south shore of Burntside lake. Rock very fine-grained mica schist, bluish and hard, and intersected by granitic veins. Rocks 63 and 64 are from this locality.

Page 47. Halt 361. For "Fig. 17" read "Fig. 18."

Page 50. For "Rock 177" read "Rock 170."

Page 56. Halt 336. For "sec. 2" read "sec. 21."

Page 57. Halt 341. For "sec 29" read "sec 20."

Page 60. For "Halt 134" read "Halt 144"; and for "Rock 146" read "Rock 140."

Page 62. Halt 309. For "T. 64-11" read "T. 63-11"; and the same under Halt 315.

Page 68. Halt 148. For "T. 63-13" read "T. 63-11."

Page 74. For "Rock 103" read "103 bis"; and in next line read "Halt 178."

Page 79. Halt 216. For "63-11" read "62-11."

Page 80. Halt 223. For "62-11" read "63-11."

Page 88. Before Halt 236 add:

HALT 234. S. E. ¼ S. E. ¼, sec. 34, T. 63-11. Coarse syenite. Low outcrop.

HALT 235. S. E. ¼ S. E. ¼, sec. 34, T. 63-11. Porphyritic syenite in two portions separated by 20 feet of fine syenite.

Expected to pass into the southern one of the long arms of Farm lake, but the outlet mapped as broad as a river is not passable for a canoe.

Page 88. Halt 236. For "73-11" read "63-11."

Page 90. For "Halt 354" read "Halt 254."

Page 91. Halt 257. For "62-11" read "68-11."

Page 95. Halt 411. For "65-10" read "64-10"; and for "Rock 169" read "Rock 179."

Page 96. Halt 419. For "S. 1¼" read "S. 16."

Page 98. For "Halt 225" read "Halt 425"; and under "Halt 432 bis," for "64-19" read "64-10."

Page 99. Halt 439. For "64-19" read "64-10"; and before "Rock 187" add:

HALT 442. S. E. ¼ S. E. ¼ sec. 33, T. 65-9. Went ashore to examine the fragments. They are mostly as heretofore, of syenite having whitish feldspar. But here are some with masses of hornblende rock; and I saved one piece in which prisms of hornblende are pretty well preserved.

Page 100. Halt 444. For "S 30" read "S. 34"; Halt 446, for "S 25" read "S. 35"; and Halt 448, for "S. 39" read "S. 35."

Page 107. Halt 649. For "S. 64-11" read "S. 14, T. 64-11."

Page 109. Halt 672. For "S. 3" read "S. 30."

Page 115. Halt 698. For "65-11" read "66-11."

Page 117. For "Halt 792" read "Halt 712."

Page 126. For "*Rock* 203" read "*Rock* 203 bis."

Page 136. Halt 566. For "65-8" read "64-8."

Page 145. Halt 741. For "S. 44" read "S. 24"; and for "Halt 774" read "Halt 744"

Page 263. Second line from bottom, for "their" read thin.
Page 263. Fifth line from the bottom, for "luminated" read laminated.
Page 381. Twenty-fourth line from the bottom, for "it" read It.
Page 391. Eighteenth line, after "of" read last gabbro.
Page 396. Fifteenth line from the bottom, for "conglomerate" read carbon
Page 149. Halt 754. For "61-7" read "64-7"; and before Halt 756 add:

HALT 873. N. E. ¼ N. W. ¼ sec. 2, T. 64-7. Chlorite gneiss—that is, c
posed of chlorite, feldspar and quartz. Seems to be of the same constituent
Rock 379, but they are well stirred together, same as at Halt 756.

Rock 380. Chlorite gneiss.

HALT 874. N. W. ¼ S. W. ¼ sec. 36, T, 65-7. West end of island.

Rock 381. Porphyrel.

Page 153. For "Rock 363" read "Rock 363 bis."
Page 160. For "Rock 324" read "Rock 325."
Page 167. Dele "Halt 820. S. W. ⅛ S. E. ¼ sec. 26, T. 65-6."
Page 170. Halt 830. For "S. 30" read "S. 36."

Errata for the report of 1887.

Page 23. Sixth line from the bottom, for "southwestern" read southeastern.
Page 37. Seventh line, for "number" read "member."
Page 70. Second line from the bottom, for "65-1 and 65-2" read 65-2 and 65-3.
Page 77. Second line, insert than before "there."
Page 82. At the bottom, for "Little" read Rattle.
Page 107. Fifth line from the bottom, for "the same" read some.
Page 168. Twenty-third line, for "if" read of.
Page 176. Twentieth from the bottom, strike out "(1069)."
Page 188. Nineteenth line from the bottom, strike out "(1104)."
Page 207. Third line from the bottom, for "latitude" read altitude.
Page 215. Third line, strike out "1177."
Page 222. Sixth line from the bottom, for "Seagull" read West Seagull.
Page 252. Thirteenth line from the bottom, for "conceded" read concealed.
Page 253. Eighth line from the bottom, for "structure" read whatever.
Page 258. Eighth line from the bottom, for "leans" read bears.
Page 260. Last line, after "65-3" insert as of Minn.
Page 270. Ninth line from the bottom, after "rock" insert (743).
Page 294. Line 23, for "(502)" read (582).
Page 294. Eleventh line from the bottom, for "573," read 593.
Page 313. Tenth line from the bottom, for "65-6" read 65-5.
Page 321. Twelfth line, before "Obscurely" insert Rock 915.
Pages 384 and 385. In the heading, for "Report, 1886" read Report, 1887.

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THE EIGHTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNE[illegible]SOTA, FOR THE YEAR 1879. 183 pp., 8vo ; one plate (Castoroides). By *N. H. Winchell*. Con[illegible]taining a statement of the methods of Microscopic Lithology, a discussion of the Cupriferou[illegible]s Series in Minnesota, and descriptions of new species of brachiopoda from the Trenton and Hud[illegible]son River formations; with reports on the Geology of Central and Western Minnesota, by *Warre*[illegible] *Upham*; on the Lake Superior region, by *C. W. Hall*; lists of Birds and of Plants from Lak[illegible] Superior, by *Thomas S. Roberts*; Chemical Analyses by *S F. Peckham*; report by *P. L Hatch*[illegible]; and four Appendices. Also in the Regents' Report for 1879 and 1880. Out of print.

THE NINTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNE[illegible]SOTA, FOR THE YEAR 1880. 392 pp., 8vo.; three appendices, two wood-cut illustrations and s[illegible] six plates. By *N. H. Winchell*. Containing field descriptions of 442 crystalline rock samples, and[illegible] and notes on their geological relations, from the northern part of the state; new brachiopoda; th[illegible] the water supply of the Red River Valley, and simple tests of the qualities of water; with reports on the Upper Mississippi region, by *O. E. Garrison;* on the Hydrology of Minnesota, by *C. M Terry;* on the Glacial Drift and its Terminal Moraines, by *Warren Upham;* Chemical Analyses by *J. A. Dodge;* a list of the Birds of Minnesota, by *P. L. Hatch;* and of the Winter Birds, by *Thomas S. Roberts.* Also in the Regents' Report for 1879 and 1880

The Tenth Annual Report on the Geological and Natural History Survey of Minnesota, for the year 1881. 254 pp., 8vo ; with ten wood cut illustrations and fifteen plates. By *N H Winchell.* Containing field descriptions of about four hundred rock samples, and notes on their geological relations, continued from the last report; the potsdam sandstone; typical thin sections of the rocks of the Cupriferous series; and the deep well at the "C" Washburn mill, Minneapolis; with Geological notes, by *J. H. Kloos;* Chemical Analyses, by *J. A Dodge;* and papers on the Crustacea of the fresh waters of Minnesota (eleven plates), by *C. L. Herrick.* Also in the Regents' Report for 1881 and 1882.

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The Twelfth Annual Report on the Geological and Natural History Survey of Minnesota, for the year 1883 Summary report, containing palæontological notes, and a paper on the comparative strength of Minnesota and New England granites, twenty-six pages, by *N H. Winchell;* final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 192 pages and 30 plates, by *C. L. Herrick;* and a catalogue of the flora of Minnesota, 193 pages with one map showing the forest distribution, by *Warren Upham.* Also in the Regents' Report for 1883 and 1884.

The Thirteenth Annual Report on the Geological and Natural History Survey of Minnesota, for the Year 1884. 196 pages. Geological reconnoissances, the Vermilion iron ores, the crystalline rocks of Minnesota and of the Northwest, the Humboldt salt-well in Kittson county, records of various deep wells in the State, fossils from the red quartzyte at Pipestone, reports on the New Orleans Exposition and on the General Museum, by *N. H. Winchell;* Geology of Minnehaha county, Dakota, by *Warren Upham;* Chemical report, by *Prof. Jas. A. Dodge;* Minnesota geographical names derived from the Dakota language, by *Prof. A. W Williamson;* insects injurious to the cabbage, by *O. W. Oestlund;* Geological notes in Blue Earth county, by *Prof. A. F. Bechdolt;* and on a fossil elephant from Stockton, by *Prof. John Holzinger;* papers on the Cretaceous fossils in the boulder clays in the Northwest, by *George M Dawson* and by *Woodward* and *Thomas;* and notes on the Mammals of Big Stone lake and vicinity, by *C. L. Herrick.*

The Fourteenth Annual Report on the Geological and Natural History Survey of Minnesota, for the year 1885. 354 pp.; two plates of fossils and two wood cuts. Containing summary report, notes on some deep wells in Minnesota, descriptions of four new species of fossils, a supposed natural alloy of copper and silver from the north shore of Lake Superior, and revision of the stratigraphy of the Cambrian in Minnesota, with the following papers by assistants, viz ; List of the Aphididæ of Minnesota, with descriptions of some new species, by *O. W. Oestlund;* Report on the Lower Silurian Bryozoa, with preliminary descriptions of some new species, by *E. O. Ulrich;* Conchological notes by *U. S. Grant;* Bibliography of the Foraminifera, recent and fossil, by *Anthony Woodward* Also supplement II of the Regents' Report for 1885-1886.

The Fifteenth Annual Report on the Geological and Natural History Survey of Minnesota, for the year 1886. 493 pp . 8vo.; 120 diagram illustrations and sketches in the text, and two colored maps; embracing reports on observations on the crystalline rocks in the northwestern part of the state, by *Alexander Winchell, N. H. Winchell and H. V Winchell;* Chemical report by *Prof. J. A. Dodge;* additional railroad elevations, by *N H. Winchell;* list of Minnesota geographical names derived from the Chippewa language, by *Rev. J. A. Gilfillan,* and notes on Illæni, describing three new species, by *Aug. F. Foerste.* Also as supplement II. of the Regents' Report for 1887-1888.

II. FINAL REPORT.

The Geology of Minnesota. Vol. I. of the Final Report. 1872–1882. xiv. and 697 pp., quarto; illustrated by 43 plates and 52 figures. By *N. H. Winchell*, assisted by *Warren Upham*. Containing an historical sketch of explorations and surveys in Minnesota, the general physical features of the state, the building stones, and the Geology of Houston, Winona, Fillmore, Mower, Freeborn, Pipestone, Rock and Rice counties, by *N. H. Winchell*; the Geology of Olmsted, Dodge and Steele counties, by *M. W. Harrington*; and the Geology of Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle and Le Sueur counties, by *Warren Upham*. Distributed gratuitously to all public libraries and county auditors' offices in the state, to other state libraries and state universities, and to leading geologists and scientific societies; the remainder are held for sale at the cost of publication, $3.50 per copy in cloth, or $5 in grained half roan binding upon application to Prof. N. H. Winchell, Minneapolis

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III. MISCELLANEOUS PUBLICATIONS.

1. Circular No. 1. A copy of the law ordering the survey, and a note asking the co-operation of citizens and others. 1872.
2. Peat for Domestic Fuel. 1874. Edited by *S. F. Peckham*.
3. Report on the Salt Spring Lands due the State of Minnesota. A history of all official transactions relating to them, and a statement of their amount and location. 1874. By *N. H. Winchell*.
4. A Catalogue of the Plants of Minnesota; prepared in 1865 by *Dr. I. A. Lapham*, contributed to the Geological and Natural History Survey of Minnesota, and published by the State Horticultural Society in 1875.
5. Circular No. 2. Relating to botany, and giving general directions for collecting information on the flora of the state. 1876.
6. Circular No. 3. The establishment and organization of the Museum. 1877.
7. Circular No. 4. Relating to duplicates in the Museum and exchanges. 1878.
8. The Building Stones, Clays, Limes, Cements, Roofing, Flagging and Paving Stones of Minnesota. A special report by *N. H. Winchell*, 1880.
9. Circular No. 5. To Builders and Quarrymen. Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the General Museum. 1880.
10. Circular No. 6. To owners of mills and unimproved water-powers. Relating to the Hydrology and water-powers of Minnesota. 1880.

IV. BULLETINS.

No. 1. History of Geological Surveys in Minnesota. By *N. H. Winchell*. In preparation.

No. 2. Preliminary Description of the Peridoytes, Gabbros, Diabases and Andesytes of Minnesota By *M. E. Wadsworth*

No. 3. Report of work done in Botany in the year 1886. By *J. C. Arthur*.

No. 4. A Synopsis of the Aphididæ of Minnesota. By *O. W. Oestlund*

No. 5. Natural Gas in Minnesota. By *N. H. Winchell*.

THE GEOLOGICAL

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N. H. WINCHELL,
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ADDRESS.

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, March 31, 1889.

To the President of the University,

DEAR SIR: I have to communicate again an annual report on the progress of the geological and natural history survey of the state, being the seventeenth in consecutive order. Like the last two, this report pertains almost exclusively to the geology of the northeastern part of the state, and is accompanied by some text illustrations.

Respectfully, your obedient servant,
N. H. WINCHELL,
State geologist and curator of the general museum.

REPORT.

I.

SUMMARY STATEMENT FOR 1888.

The work done in the season of 1888 in consequence of the supplementary aid that was rendered the survey by the special appropriation and law of the Legislature of 1887, as mentioned in the last report, will be found reported elsewhere. The explorations for natural gas carried on within the state, whether by private enterprise or by the aid of the special fund, are detailed, with some considerations relative to the general subject of gas in Minnesota, in Bulletin No. 5. The special field-work which was directed, under the same law, to the discovery and definition of the iron-resources of the northeastern part of the state, will be included in this report. But the whole subject in general of the geology of the iron ores of Minnesota will find place in Bulletin No. 6.

There were two parties in the field during the season. One was occupied, in the first part of the season, in making collections of rock-samples from certain typical crystalline formations in typical localities. This was under the direction of Mr. Uly S. Grant. At the same time some new facts were observed. These, with notes made by him later in the season when occupied more specially with the examination of the iron-ore beds, are gathered together by him in a formal report which accompanies this.

The other party was during the whole season at work on the iron-ore beds. This was under the guidance of my son, Mr. Horace V. Winchell, whose report on his work will also be found accompanying this

The work of the season has added materially to our exact knowledge of the geology of the northeastern part of the state, and particularly to that of the nature and relations of the iron ores of the state. A general presentation of this knowledge, in a somewhat systematic manner, has been attempted in this report; but it must be admitted, notwithstanding the time spent on the study, and field-observations that have been recorded, there are still some important, and many less important, questions which the survey cannot answer. But with a consciousness that, however exhaustive the research might be made, there would be questions still unsolved, and that there is a general wish for a full and "final" presentation of the geology of that part of the state so far as present knowledge will yield it, and also feeling that the time has been long that the survey has been going on, and that the working span of one man's life cannot be depended on for indefinite extension, I am constrained to say that we shall enter now upon the preparation of the final report covering the northern part of the state. There will be some supplementary examination to be made, but this will be not very costly, and can be executed while the preparation of the report is in progress.

Volume II of the final report was issued in December, 1888. It is a quarto of about 700 pages, forty-two plates and thirty-two figures, of the same style as Vol. I.

A considerable portion of Vol. III is also ready, and the entire volume will be finished at once. It will contain, along with the paleontology of the strata discussed in Vols. I and II, an account of their systematic relations to the geology of the Northwest. There is also, in readiness for publication, a volume devoted to the birds and mammals of the state, prepared by Dr. P. L. Hatch and Prof. C. L. Herrick. These two volumes should be published at once, in style uniform with those already issued.

The monograph of Messrs. Woodward & Thomas on the microscopic fauna of the Cretaceous, which has been in process of preparation several years, has been completed by those gentlemen and has been transmitted for publication. It will form a chapter in Vol. III. Mr. Ulrich's work on the bryozoa of the Trenton was interrupted unfortunately, when it had proceeded so far as the engraving of the plates, eight having been completed and delivered. This was owing to the exhaustion of the fund for publication by the unexpected cost of Vol. II. Dr. Leo Lesquereux's report on the fossil flora of the Cretaceous in Minnesota, with the accompanying plates, is also intended for Vol. III. It is only an act of reasonable justice to a scientific author that his contributions be published as soon as possible. His rights are not all satisfied by the simple payment of the money involved in his contract to prepare the report. The value of scientific work, especially scientific authorship, is not measured by the manual labor involved in it. So its claims are not satisfied when the material money payment is made. The author expects, and he has a right to demand, that his work shall be published. His researches, so far as they are in new fields, may be covered by later investigators and be announced before his see the light. This reward for scientific authorship, while it cannot be expressed in dollars and cents, and cannot perhaps be included in definite terms in the contract with the author when he undertakes the work of any investigation, yet acts as a powerful stimulant and as a final element in the compensation he reasonably counts upon. He naturally is backward in asserting it; and it is a lamentable fact that credit for some valuable research and some discoveries has been lost to their authors because of the suppression, or at least the tardy publication, of their reports until after others had made the same discoveries and had announced them to the public. In the case of a state survey such delay not only injures the individual but also reflects on the value of the official reports. Wherever scientific facts are first published, there they are forever acknowledged and referred to by future authors. If the state has incurred the cost of an investigation, its chief value is lost if the credit of its discoveries cannot be secured by early publication, and if the same facts are published elsewhere.

The condition of the museum and of the unexamined specimens is about as has been stated in some of the late reports. Not only are the museum halls full to overflowing, but the so-called laboratories of the survey are also full. It has become necessary to deposit the boxes of rock samples in these rooms. All the packing, handling and labeling has been done heretofore in these rooms. Recently, owing to the storage of a large part of the surplus copies of Vols. I and II in these rooms, there has not been room left for doing this work, and it has been transferred to the office, on the second floor of the building.

A record of museum accessions is herewith again reported, the same having been crowded out of the last two reports. Its publication subserves the double purpose of acknowledging donations and of permanence of a record easy to consult in case of desire to find any specimen in the museum, or any information concerning any specimen when once the specimen is in hand. The method of labeling all specimens collected has been found very safe and permanent. It consists of mixing a solution of common shellac, such as can be got of a druggist, with some coloring material and carefully placing the numbers with a small brush or with a stick, on the specimens, by hand. The shellac, being dissolved in alcohol quickly hardens by the evaporation of the alcohol, and embracing the coloring material in the hardened mass, has the quality of permanence of color and insolubility in water. The upper right hand corner of the specimen is used. In case the natural surface is rough, or if the color of the letter to be attached would be so nearly the same as the rock as to render the designation indistinct, the surface is first colored over in a small rectangular spot with some other color of the same kind of material, and when hardened the number is applied over it. The specimens have been numbered as below.

The regular museum series, such as have been placed on exhibition, whether rock-samples, minerals or fossils, have their numbers in *red*, produced by mixing the shellac with "vermilion red."

The series of N. H. Winchell, mainly crystalline rocks, are marked *blue*, produced by mixing indigo with the dissolved shellac.

The series of A. Winchell, also crystalline, are marked *black*, produced by mixing the shellac with india ink.

The samples collected by H. V. Winchell are marked *pink*, a mixture of vermilion red and white lead with the dissolved shellac.

The samples collected and reported by Mr. U. S. Grant are marked *green*, made by mixing the shellac with paris-green.

The specimens in the archæological collection are marked in *white*, mixture of white lead with the dissolved shellac.

The list of museum accessions herewith reported includes only those marked in *red*. All others are listed in connection with the respective field reports.

The crystalline rocks of Minnesota. General report of progress made in the study of their field relations. Statement of problems yet to be solved.

CONTENTS.

Introduction.

1. Work done by the Minnesota survey on the crystalline rocks.
    - (a) Early views. State of knowledge when this investigation was begun.
    - (b) The problems then unsolved.
    - (c) List of publications issued since the Minnesota survey began.
    - (d) The various annual reports.
        - The first annual report, 1872.
        - The second annual report, 1873.
        - The sixth annual report, 1877.
        - The seventh annual report, 1878.
        - The eighth annual report, 1879.
        - The ninth annual report, 1880.
        - The tenth annual report, 1881.
        - The eleventh annual report, 1882.
        - The thirteenth annual report, 1884.
        - The fifteenth annual report, 1886.
        - The sixteenth annual report, 1887.
        - Bulletin No. 2, M. E. Wadsworth, 1886.
2. The various steps of progress.
3. The results of the investigation so far as they appear at present.
4. Comparison of these results with those reached elsewhere.
    - (a) Agreements.
    - (b) Disagreements.
5. Problems still unsolved.

INTRODUCTION. In the course of any investigation that is extended over a number of years, like that of the work of the survey on the crystalline rocks of the state, it is necessary, for an intelligent application of effort, to review the progress made and ascertain as nearly as possible the amount and kind of work that remains. It is one of the characteristics of geological investigation, and particularly of research among the crystalline rocks, that as difficulties disappear, under the reflective scrutiny of the laborer, new problems are presented for solution. In the solution of these more advanced problems the geologist sometimes forgets, in the eagerness of his pursuit, that it is incumbent on him, in the interests of his own work, as well as for the information of others, to render an account of his progress and of his success in surmounting the difficulties that confronted him at the outset. There are but few investigators, in any branch of science, that have not made mistakes. They may have advanced under illusive guides along devious lines, they may have retreated where they ought to have advanced, or advanced where they should have retreated. They have entertained partial or wrong opinions; but it is evident that no one should be held to these errors that are incident to the process. The final statement only ought to stand for the result of the investigation. This may contravene, or it may modify or totally disprove some of the early views. There is hence a justifiable reluctance on the part of an investigator to publish his results till he is satisfied that he is right, and that the work is finished. In the case of the Minnesota survey, however, like all surveys, it ought to be "finished." That is, its work should be rounded out with a so-called completion; for it is evident that however far the work should be continued there would still remain unsettled questions. It is not within the power of one survey, nor of one generation, to exhaust the possible research that might be applied to the examination of the geology of the crystalline rocks.

For these reasons it is thought best to take an inventory of the survey's work and results in the examination of the crystalline rocks of the state. This will be preliminary only, and the apparent truth, as it may be expressed in this report, may appear different in the light of future discoveries, and the final report on this work may be somewhat different from that which is here foreshadowed.

1. WORK DONE BY THE MINNESOTA SURVEY ON THE CRYSTALLINE ROCKS.

The efforts of the survey have been directed, almost wholly, to the field relations of the terranes. It is evident that all laboratory determinations are subordinate, in their bearing on the general geology, to the labor expended in the field. That which is of first importance is a knowledge of the facts as to superposition, transition, and extent of the various kinds of rocks as they exist, in fact. No fine mineralogical disquisitions, or chemical determinations, or stratigraphical suppositions, or historical reviews of past speculations, can bear the weight of a feather in the balance against the facts of field observation. Dr. M. E Wadsworth has truly said[*] that the field evidence must in all cases be the arbiter and guide to the conclusions of the microscopist in his laboratory work on crystalline rocks, as to their eruptive or sedimentary nature. This supposes that the facts as reported are the actual facts. It is true, however, that from different standpoints the same facts may be reported differently by different observers, or because of a lack of capacity or training in field observation on the part of one or the other.[*] So far as the work of the survey is concerned, while it would be obviously absurd to assert that no mistakes of field observation have been made, and no incorrect inferences have been arrived at by the field observers, it is no more than the facts of the case will justify to say that the Minnesota survey has devoted more time and accumulated more exact knowledge regarding the field-relations of the crystalline rocks than has any other state survey; and probably has given more time to field work in the crystalline rocks of the Northwest than the United States geological survey. In some instances extensive routes of observation have been gone over more than once for correction or verification. These field observations have been reported in whole or in part, from time to time chronologically in the reports of progress, but their fragmentary parts have not been grouped and presented systematically so as to show the results as they appear in the mind of the writer.

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[*] Notes on the geology of the iron and copper districts of Lake Superior, p. 74.

(a) *Early views. State of knowledge when this investigation was begun.*

When the Minnesota survey was begun, in the fall of 1872, there had been but little done on the crystalline rocks of the Northwest. In addition to the desultory and often fragmentary work of the Canadian survey, which should be classed rather as exploration and sketch-mapping, and which had been spread over the Canadian shores of lake Superior as far as to Pigeon river by Mr. Robert Bell, the only published information respecting the older terranes in Minnesota was in the reports of Keating, Allen and Schoolcraft, Shumard, Norwood, Whittlesey and Hall, with some brief notes by Bigsby, on the Lake of the Woods. Douglas Houghton had also visited Grand Portage and some points further west. Eames & Hanchett had also rendered short reports on some features of the northern part of the state.[†] There had been published also, in 1871, in the *Zeitschrift d. Deutschen*

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[*] Compare Irving's and Wadsworth's different observations on the "Eastern Sandstone," *Copper-bearing rocks of lake Superior*, Monograph No. 5, U. S. Geol. Survey, p. 356, et seq.

[†] See Vol. I. final report, for some account of these early publications.

geologischen Gesellschaft, a paper by Dr. J. Kloos giving some notes on Minnesota, in which important new observations were recorded. It was two or three years later, however, that this last paper was first known to the writer.[*] Prof A. Winchell and Prof. R. D. Irving had also made some observations on the geology of the Northwest, particularly in Michigan and Wisconsin. The report of Foster and Whitney on the copper and iron districts of the lake Superior region makes no mention of the geology of Minnesota further than the reported occurrence of one or two minerals on the north shore of lake Superior.

So far as any of this work touches the geology of Minnesota, in the areas of the crystalline rocks, it may be divided into two classes.

1. That which is descriptive of the geographic extent of the crystalline rocks.

2. That which by careful mineralogical determinations discriminates the rock species from each other, or classifies the formations stratigraphically.

In the former may be placed the reports of Keating, Allen, Schoolcraft, Shumard, Eames, Hanchett and Houghton; in the latter are the reports of Norwood, Whittlesey, Hall and Kloos. Norwood's report partakes largely in the character of the first group. Whittlesey's was the result of observations made in company with Norwood, and embraces about the same facts and conclusions. Prof. James Hall's report of a trip from St. Paul to lake Shetek[†] in 1866, embraces the first reference of any of the crystalline rocks of the state to their supposed stratigraphic equivalents in the eastern states and Canada. He distinctly refers the gneisses at Redwood Falls to the *Laurentian*, and the quartzytes at New Ulm and Pipestone to the *Huronian*, names which had been adopted by the Canadian geologists, though with some ambiguity and overlapping of description, the former in 1854,[§] and the latter in 1857,[§§]

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[*] See transalation of this in the tenth anual report.

[†] 1866, Trans. Am. Phil. Soc., Philadelphia, p. 329.

[§] Geol. Report Can. Survey, 1857, p. 7. The name was used in "Sketch of the Geology of Canada," printed in French in Paris, 1855. This is embraced in "Canada at the Universal Exposition of 1855," by J. C. Tache, a report printed at Toronto, "by order of the Legislative Assembly," 1856. It was first announced in the report of the survey for 1852–53, which, however, was not published till 1854, at Quebec.

[§§] In Mr. Murray's reports for 1853, 1854, 1855 and 1856 the terms "Huronian system" and "Laurentian system" are used incidentally, and as headings to chapters; but as these were not offered for publication by Mr. Logan till March, 1857, they cannot be considered as official announcements of those names till the date of their actual publication.

Just prior to the adoption of these terms, expressive of a distributive chronological classification of the terranes of the crystalline rocks, at least all those lying below the Potsdam sandstone, Messrs. Foster and Whitney[*] had employed the term *Azoic*, after Murchison and Verneuil,[†] and had divided them mineralogically rather than chronologically, into gneiss, mica and hornblende slate, chlorite, talcose and argillaceous slate, quartz and marble.[‡] They considered them an indivisible complex series, whose foldings and metamorphic changes rendered a determination of their original stratigraphic order impossible. This term, with its significance as interpreted by Foster and Whitney, was adopted by Dana in the first and second editions of his Manual of Geology (1862 and 1864), and by the Vermont geologists in 1862 (Geol. of Vermont, Vol. I). It was not till 1874 when the third edition of this manual was issued (by some mistake also called "second" edition), that the terms used by the Canadian geologists were adopted in this work. They are continued in the fourth ("third") edition issued in 1879. Dr. Ebenezer Emmons evidently shared the views of Foster and Whitney. Aside from his opinion that the Huronian of Canada was only a synonym of his Taconic which he insisted was not "Primary," he divided the "primary" rocks into two groups,[||] based on the varying theoretical agency of heat in their production and present condition, viz., *pyro-crystalline* and *pyro-plastic.* In the former, in the main, he embraced granite, gneiss, mica slate, talcose slate, hornblendic and hypersthene rocks, that is to say, speaking broadly, the acid eruptive rocks and their accompanying schists, and in the latter he included the most of the basic eruptives.[§]

When the Minnesota survey began [1872] the Wisconsin survey, lately completed by Chamberlin, had not yet been instituted.[§§] and the Michigan survey, revived in 1869, did not present its first final volume for publication till May 1, 1873. The writer, having been at work in 1870 on the Michigan survey, was, however, acquainted with the views of the director, Prof. A. Winchell, and of major T. B. Brooks, the geologist of the iron regions, touching the equivalency of the Marquette iron formation to the Huronian of Canada, as subsequently announced in Volume I of that report.

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[*] Proc. A. A. A. S. 1851, p. 4.

[†] The Geology of Russia in Europe, Vol. I, p. 10.

[‡] Report on the Geology of the lake Superior land district; part II. p. 2. Am. Jour. Sci., (2) xxiii. 305.

[||] Manual of Geology, Second edition, 1860, p. 52.

[§] Emmons also regarded some limestones as pyro-crystalline, and he embraces it in both series of that class of rocks. Op. cit. p. 60 et 66.

[§§] The law ordering the Wisconsin survey was approved March 18, 1873.

The first volume of the New Hampshire report by Prof. C. H. Hitchcock was issued in 1874, and that devoted to the stratigraphic geology of the Archæan in that state in 1877.

(b) *The problems, therefore, that were then unsolved*, touching the stratigraphy of the Azoic or Archæan, were as follows:

1. Could the Azoic be divided stratigraphically with any probable general applicability?
2. Could the terms Huronian and Laurentian, as employed by the Canadian geologists, find any equivalents in the crystalline rocks of Minnesota?
3. What relation did the Huronian bear to the Cambrian?
4. What relation did the Huronian bear to the Taconic?
5. What relation did the Cambrian bear to the Taconic?
6. What relation did the Animikie bear to the Taconic, the Cambrian and the Huronian?

Correlatively with these problems appeared others, although they did not present themselves so forcibly till some time later, viz.:

7. Could the rocks classed as Laurentian be distinctly shown to be of older date than the Huronian? All of them, or a part of them?
8. Could the Laurentian be subdivided?
9. Is the Laurentian derived from originally sedimentary rock? or from primarily eruptive rock?
10. If originally sedimentary, or if primarily eruptive, why is it mainly an "acid" rock?

(c) *Publications issued since the work began.*

In an appendix is a list of publications that have been issued since 1872, bearing on the geology of the crystalline rock, of the Northwest, so far as the writer has learned of them. It is probably not complete, but certainly embraces everything that has contributed to the subject any important information. To all of these the writer must acknowledge great indebtedness, and to none greater than to the geologists of Michigan and Wisconsin, Maj. T. B. Brooks, Dr. A. Winchell, Prof. R. Pumpelly, Dr. C.

Rominger, Prof. C. E. Wright, A. R. Marvine, Prof. R. D. Irving, Prof. (now President) T. C. Chamberlin, E. T. Sweet, and to Prof. M. E. Wadsworth, now state geologist of Michigan.

(d) *The various annual reports: progress from year to year.*

That there has been some advance in the science of the crystalline rocks in America at large as well as in those of the Northwest, and of Minnesota specifically, since 1872, is evident from a comparison of the problems unsolved in 1872 with those that are presented to the geologist in 1889; and while this advance is mainly due, of course, to the labor of the authors whose works are listed above, some of the steps of this progress may be accredited to the Minnesota survey. Some of these steps, due to a large extent, or wholly, to the Minnesota survey, it will be appropriate here to enumerate. There may be still a difference of opinion among the geologists of the United States and Canada as to what constitutes a step of progress, and as to who should be regarded as its author. But it is the design of the writer to mention only those steps which appear to his judgment to be actual advances, whether they appear so to others or not, and in that he holds no one responsible but himself. As to the responsibility and the credit for these steps, that is decided, as in all similar cases in science, by the dates of the published literature that announces them. The record, therefore, which will here be given, will be that of the progress, mainly, of the writer's own mind and apprehension of what he considers successive advances.

The first annual report, 1872.

The first annual report was made before any time had been allowed for examination of the crystalline rocks of the state by the present survey. Therefore the only design was to express concisely the state of knowledge that then was available, so far as it bore on any classification that might be accepted. The views of Foster and Whitney as expressed in 1851,* grouping the crystalline rocks in the same manner as Murchison and Verneuil, all in one system under the name Azoic,** were cited and their table of stratification was quoted. At the same time the subdivision into Laurentian and Huronian, introduced by Logan and Hunt

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***Report on the Geology of the lake Superior land district.* Part II, p. 8. *Proc. A. A. A. S.* 1851, p. 4

** Geology of Russia, Vol. I, p. 10.

of the Canadian survey, though contested by Prof. Whitney, was generally prevalent, and these terms were included in the brief description then published of their extension into Minnesota.

The most important question, however, which was considered in the first report, bearing on the classification of the Laurentian and Huronian, was that pertaining to the *Potsdam sandstone.* The bearing of this discussion, however, upon that classification was not fully apprehended, as its application and significance have been brought to light in some of the later years of the survey. Drs. Owen and Norwood, as well as A. Winchell * considered the red sandstones and quartzytes of Wisconsin and Minnesota as the conformable downward extension of the light-colored sandstones of the St. Croix and Mississippi valleys which they parallelized with the Potsdam of New York. It was just before the commencement of the Minnesota survey (Feb., 1872, Am. Jour. Sci., p. 93), that Prof. R. D. Irving demonstrated conclusively that at Baraboo, Wisconsin, there was a marked unconformity between the red and the light-colored sandstones, and that they could not belong to the same system. Prof. Irving coincided with Prof. James Hall,** who had previously regarded the light-colored upper sandstones as Potsdam and had been followed by nearly all geologists of America, in referring the lower quartzytes to the Huronian of Canada.

The first report of the Minnesota survey refers the lower quartzytes to the Potsdam horizon of New York and gives the name *St. Croix* to the overlying light-colored sandstones. In the light of all subsequent examinations, both east and west, there has appeared nothing that has disproved the correctness of this reference, but on the other hand every fact, whether of paleontology or of stratigraphy, which has been brought out since 1872, relating to this horizon, has been in accord with it. It must not, however, be considered as sufficiently demonstrated, so long as there are competent dissentients who still restrict the name Potsdam to the later sandstones. It will appear later in what way this bears on the classification of the rocks styled Azoic by Messrs. Foster and Whitney and later Archæan by Prof. J. D. Dana.

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* Owen's report on Wis., Iowa and Minn., pp. 48, 187, and Table, p. 634. Am. Jour. Sci. (II) xxxxii. 226, 1864.

** Report of progress to the Governor of Wisconsin, 1860; also Notes upon the geology of some portions of Minnesota from St. Paul to the western part of the state, *Trans. Am. Phil. Soc.* Philadelphia, June, 1866.

The second annual report, 1873.

In the second report was an account of the geology of the Minnesota valley. While this entered into a somewhat detailed description of the field appearances of numerous outcrops of the crystalline rocks between New Ulm and Big Stone lake, there was no attempt made to classify them, or to refer them to any horizon of rocks exposed in the northern part of the state. They were regarded as a southern extension from the granites in the northern part of the state, and were presumed to have their parallelisms there if they could be referred to their proper places. The red quartzyte at (or near) New Ulm is again referred to the age of the Potsdam.

The sixth annual report, 1877.

The report contains the first recorded observations made by the Minnesota survey on the crystalline rocks of the northeastern part of the state. They were made at Northern Pacific Junction and about Little Falls, on the Mississippi river. An examination was also made of the granitic rock in the vicinity of Motley. These notes are simply descriptive, without any effort at classification.

In this report is a description of the geology of Rock and Pipestone counties, in which are large outcrops of the same red quartzyte as seen at New Ulm, and at Baraboo, Wisconsin. It is classed as Potsdam.

The seventh annual report, 1878.

In the seventh report is a sketch of a somewhat extended systematic examination of the mining geology of the northeastern part of the state. The coast of lake Superior was examined from Duluth to Pigeon point, a trip was made overland from Grand Portage along the international boundary to Basswood (or Basimenan) lake, thence to Vermilion lake, the St. Louis river, across to the Mississippi and down that river to Little Falls. Some examination was also made of the country between Pigeon point and the Brule river by ascending some of the valleys from the shore of lake Superior. Among the geological results of the season's field work, as stated in the report, on p. 10, are the following points which may be classed as advances in classification of the crystalline rocks of the state.

1. The syenites, granites and other rocks that had been named

Laurentian by the Canadian geologists graduate conformably into the schists and slates that had been named Huronian by the same—as designated and defined by Mr. Robert Bell. This is also stated by Mr. Bell in his report for the Canadian geological survey, 1873.* This definition, however, of the Huronian formation, as will appear later in this summary, was incorrect, and the correction was made by Mr. A. C. Lawson who named the schists *Keewatin series.*

2. The gray quartzyte formation, No. 4 of the seventh report, is the iron-ore formation of the Mesabi range and graduates conformably into siliceous iron-charged rock, "which in some places furnishes a valuable iron ore in large quantities."

3. The Cupriferous formations, later known as the Kewenian, or Keweenawan, lies unconformably over several formations, and is interstratified with the beds of the latest.

The evidences of these conclusions are not given in this report. The detailed observations have not yet been published, but a synopsis of them was published in connection with a preliminary description of rock samples collected, in the ninth annual report.

The eighth annual report, 1879.

So far as the eighth report records the work of 1879 on the crystalline rocks, it embraces the descriptive account of the outcrops in the Minnesota valley by Mr. Warren Upham, and some mineralogical notes on the eruptive ranges of the lake Superior region by Prof. C. W. Hall. The observations of the writer in the northwestern part of the state, in 1879, have never been published in full, but a synopsis of them was published in connection with a preliminary description of rock samples collected, in the tenth annual report.

In a preliminary chapter are some mineralogical notes on the "Cupriferous series at Duluth" (p. 22). In this a distinction is drawn between the labradorite rock, or "gabbro," and the red orthoclastic syenite which is mingled irregularly with it, the latter being regarded as the result of local fusion of some of the sedimentary strata, probably some of the strata of the Cupriferous series. The whole trap and Cupriferous series of lake Superior is here assigned to the age of the Potsdam sandstone.

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*Report of progress, 1872-3, p. 106.

The Ninth annual report, 1880.

This report gives a preliminary description of 442 rock samples collected in the region of the crystalline rocks northwest from lake Superior, in 1878, with a running brief commentary on their field relations. It contains but little attempt at classification of the stratigraphy. A distinction of unconformity is made on p. 82 between the gray slates and quartzytes of the south side of Gunflint lake and the hydromicaceous rocks of the north side, the two being separated by a conglomerate-breccia, and the more northern rocks being regarded as the equivalent of what the Canadian geologists had styled Huronian. This conception of the Canadian Huronian was derived from Dr. Hunt's having described the Huronian as in the main a mass of greenstones, and Dr. Bell's report on the region westward from Thunder bay in 1872. Observations are recorded on p. 94 indicating a conformable passage from what was then regarded as Huronian to the lower syenites, or Laurentian.

The tenth annual report, 1881.

The preliminary description of rock-samples is continued in this report, embracing those collected in 1879, and extending the list to No. 836 inclusive. There is also a renewed discussion of the Potsdam sandstone and its western equivalents, and a short description of some typical thin sections of the rocks of the Cupriferous, or Kewenawan, in Minnesota.

This report embraces some attempt at partial classification, stratigraphically, of the crystalline rocks.* The strata that comprise the island at Grand Portage bay are described in detail, with references to the rock-samples illustrating them. This is followed by a "Generalized section of the alternating beds of the formation," and of the Animikie (Taconic) and lower terranes to the granites and syenites of the region north of Gunflint lake. It is as follows:

Generalized section at Grand Portage and northwestward to Gunflint lake.

1.	The Palisade rock, or the "red rock."	
2.	Green shales, etc., in the bay east of Red point (Nos. 232, 235 and 239).	
3.	Layer of trap, like 540 (542) seen..	14 feet.
4.	Chalcedonic amygdaloid (543) seen..	20 feet.

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*See pp. 47, 49, 87, 94, 112, 123-136.

5. Fibrous green trap striking E. and W. through the island and forming its highest parts. In spots it is globuliferous with hard, dark, strong, shot-like pellets about ¼ inch in diameter, (Nos. 544 and 545).. 35 feet.
6. Even-grained sandrock (546) seen.. 8 feet.
7. Trap bed, finely and irregularly jointed, with nodules of white saccharoidal calcite (547) seen.. 36 feet.
8. Quartzyte (548) seen.. 5 feet.
9. Conglomerate (549) seen.. 16 feet.
10. The rock No. 540, forming the great trap covering of the quartzyte hills at Grand Portage; seen 50 ft.; estimated .... 250 feet.
11. The slate and quartzyte terranes seen in the hills at Grand Portage, generally, and along the international boundary as far west as the west end of Gunflint lake, estimated................ 400 feet.
12. Jasper and iron-ore beds of the Mesabi, and southeast of Vermilion lake.
13. The micaceous and chloritic schists and slates of Vermilion lake and the dalles of the St. Louis river.
14. The mica schists, granites and syenites of the region north of Gunflint lake.

This takes no account of the great labradorite range, which in some places forms the Mesabi, nor of the iron-ore deposits of Mayhew lake, because these are apparently included in the rock Nos. 258 and 540, or in an immense outflow of molten matter at a date somewhat earlier (V. No. 695 and 816). Nor does it mention the conglomerate at Ogishke Muncie lake, because that is apparently an incident of the slaty and talcose beds included in sub-No. 13; nor the red granite of the region of Brulé Mt., because they are probably a modified condition of the Palisade rock.

Respecting the parallels of the quartzyte strata composing a part of Isle Royal, so far as found in Minnesota, the following statement is found on page 49.

Its dip, color and bedding recall the red quartzyte in S. W. Minnesota, but it is rather less siliceous than that. In the same manner, however, it overlies a coarse pebbly conglomerate, which in the same way indicates its relation to the red quartzyte of Grand Portage island and of Pigeon Point peninsula (No. 290), as well as to the sandrock and shales of Fond du Lac.

Not at that time having realized the fact of the existence of two hematite iron-ore horizons, in two separate and unconformable formations, there are some intimations of the confusion of stratigraphic interpretations which the writer discovered when the effort at general classification was undertaken. Thus, on page 94,—

The "Gunflint beds" (i.e., the jasperoid beds) south of Gunflint lake (see after No. 747) have been associated with the slates and quartzytes of the overlying formation (i. e., the Animike) rather than with the talcose, slaty beds underlying (see 426), but observations about Town Line and Ogishke Muncie lakes seem to indicate that they are here a part of a schistose, slaty formation, highly inclined, which belongs to the Huronian (i. e., as the Huronian had been described in the region) passing into the great conglomerate of Ogishke Muncie lake."

At the same time the conglomerate about Ogishke Muncie lake was regarded as a single formation, and, while in all descriptions and sections that had been given, it had, as a totality, been grouped as a part of a terrane separate from the Animike, yet there were stated to be some considerations that seem to require it to be considered a part of the Animike (p. 95); and that the horizontal slates (the Animike) as a whole may also pass into the tilted slates as a whole. It will only be necessary to state that this latter idea was one of the errors that are inseparable from the progress of any such investigation. It was recorded at the time as expressive of the stage of interpretation of the facts that had then been reached. Yet it was not wholly erroneous. The facts appealed to, conflicting as they appeared then, are facts still, and they go with numerous other observations to force the abandonment of the idea that the Animike is convertible into the "talcose" or sericitic slates and schists of the region further west, although they do become highly tilted. The former idea, however, when separated from the latter, and supplemented by further statement in harmony with a wider field of observation, has stood the test of all the study and observation that have been devoted to this point, and may be considered as a step of progress, *viz.*, The formation of horizontal slates of the vicinity of Gunflint lake and the international boundary is the same as the highly tilted slate and quartzyte formation that passes into the slaty conglomerate of the region of Ogishke Muncie lake.*

In regard to the epoch of the great outflow of the labradorite rock, the "gabbro," some general statements are given on pages 112 and 113, based on observations at Beaver Bay, which show that this rock preceded the advent of the bulk of the eruptive traps of the Cupriferous. The conclusions are in these words:

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* Prof. Irving and the Wisconsin and Michigan geologists, as well as all the Canadian geologists except Dr. A. C. Lawson, so far as known, regard these horizontal slates when broken and tilted and the tilted schists as both included in the Huronian; and Prof. Irving has referred to this hypothetical conversion of one to the other in support of that view. (Copper-bearing rocks of lake Superior, Mon. V., U. S. Geol. Sur., p. 443.)

(1) The Great Palisades are of a rock, the equivalent, geologically, of the slaty quartzyte (Nos. 127 and 528) at Beaver Bay, and below that point; and to the red syenite of the islands below Beaver Bay, and of the west bluff of Beaver bay; and to the red (often quartzless) rock associated with the gabbro at Duluth. These beds also constitute the red bluffs at Tischer's near Duluth, and New London, as well as the red rocks at Baptism river and the East Palisades.

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(2) The feldspar masses are of the same rock (geologically) as the Rice Point gabbro, and both are the result of copious, and perhaps one of the earliest, igneous outflows of the Cupriferous. * * * The late outflows derived fragments from the "clinker fields" and from the knobs of feldspar already formed, as they passed along; and when these had been covered by later sedimentation such sedimentary beds were also involved in the later upheavals and fusions.

The "slaty quartzyte" here mentioned as the probable equivalent of the Palisade rock, is a firm, purplish felsyte containing some angular quartz grains.

In the discussion of the question—what are the western equivalents of the Potsdam sandstone—the tenth annual report records some departures from the conclusions of the Wisconsin geologists, and reverts to the opinions expressed in the first annual report, to the effect that the Potsdam sandstone of New York is not found at all in the bluffs of the Mississippi river, but that it is more likely to be represented by the red sandstone and shales that constitute, with the associated eruptive rocks and conglomerates, the Cupriferous or Kewenawan formation of lake Superior. It maintains that the Taconic system was established correctly by Dr. Emmons, and that it is repeated in the Animike of Thunder bay, as well as in the Georgia group of Vermont. This last is an important step of progress, in the opinion of the writer, and one that no later discoveries have tended to invalidate. This conclusion was reached by a comparison of the described stratigraphy and the paleontology of the formations involved in the east, with those of the west. The Potsdam sandstone, or quartzyte, in both places lies probably unconformably over the Taconic.

The eleventh annual report, 1882,

While containing some matter relating to the mineralogy and lithology of the state, also embraces a table of the systematic geology of the crystalline rocks. This represents the "Huronian" as extending from the Potsdam formation through the

Taconic, also embracing the formation since named Keewatin by Dr. A. C. Lawson, and the mica schists since named (in the report for 1886) Vermilion group* by this survey. The black slates and the quartzytes of the Animike and the Ogishke Conglomerate are made the equivalent of some of the Taconic. This includes also the iron-bearing rocks of the Mesabi range and Vermilion lake, the "Gunflint" beds and the slates and quartzytes at Thomson. The magnesian sericitic schists of the region of Vermilion lake and north of Gunflint lake, while placed below the Taconic and above the mica schists (which are styled "Montalban?") are doubtfully supposed to represent the true Huronian.

Prof. A. H. Chester, in this report, parallelizes the iron districts of Minnesota, i. e., the Mesabi and the Vermilion ranges, both with the "Huronian," and specially dwells on the resemblance of the Mesabi iron-bearing rocks to those of the Penokee range in Wisconsin. He also calls special attention to the close geological similarity between the Vermilion iron deposits and those of Marquette.

The thirteenth annual report, 1883.

In this report is found the first statement that indicates the necessity of separating the Vermilion ore horizon from the Mesabi ore horizon. See pp. 24, 37. It is here assigned to the formation of "Huronian conglomerates and greenstones" (see Fig. 5, p. 22), the same that in the eleventh report was described (p. 170) as "magnesian, greenish, soft schists, becoming syenitic and porphyritic; seen on the north side of Gunflint lake, along the international boundary at Basswood lake, and at Vermilion lake," the formation of graywackes and sericitic schists which has since been designated Keewatin, the same that in the ninth report was said to be unconformably under the Animike at Gunflint lake.

This report also describes primordial fossils from the red quartzyte of southwestern Minnesota, the same that Prof. James Hall had classed as Huronian, and that had been also regarded Huronian by the Wisconsin geologists. These fossils are *Lingula calumet* and *Paradoxides barberi*, and the beds containing them are supposed to be represented in the lake Superior region by the red quartzyte at the head of Wauswaugoning bay and on

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* About the same time the Vermilion group was named *Coutchiching* by Dr. Lawson. Am. Jour. Sci. (3) xxxiii., p. 473.

Pigeon point, which in the tenth report was supposed to be extended to Isle Royal.

The fifteenth annual report, 1886.

A large amount of field-work was done in 1886. It added much to the evidences of the correctness of the general parallelisms that had been gradually wrought out by the survey. It also introduced some new problems, and showed the necessity of instituting some subordinate divisions in the formations that had been spoken of in other reports. It also showed the necessity of abandoning some of the hypothetical parallelizations that had been entertained.

In respect to the gabbro formation, the Mesabi overflow, it was found to be indistinctly separable from another, and earlier, eruptive rock which constitutes a prime feature in the topography, and which occupies a wide belt of country running along north of the gabbro area, its line of direction being rudely parallel with the north limit of the gabbro. A general representation of the geographic areas of the various formations was attempted on a colored geological map of the northeastern part of the state. The gabbro was found to have extended so far north as to have covered from sight the line of strike of the Animike (p. 381) and to have come into contact with the older syenite (pp. 347-49). It was intimated that the Animike formation overlay one eruptive rock and underlay the other, and that it seemed to embrace the Ogishke Muncie conglomerate in its lower portion (p. 381). The entire eruptive rock was found to be in some places a remarkable agglomerate, and in various ways to become changed to greenish schists, chloritic and sericitic, and to embrace in its mass, generally in a manner of unconformity, the jaspilyte and iron-ore of the Vermilion lake region. At the same time this green rock exhibited at times very manifestly some signs of aqueous stratification; at other times no such structure could be found in it, and it merged into a dense, homogeneous, massive doleryte. The graywackes which are in this greenstone formation, fade out by merging into its evidently eruptive condition, but in many places are purely sedimentary, having much quartz as rounded grains and pebbles, arranged in sedimentary layers.

The mica-schist belt which was shown to be stratigraphically below the graywacke-greenstone horizon was named ***Vermilion*** group, or series. It was said to merge into the gneisses below sometimes conformably and at others to be united with them through a series of mutually intersecting dikes, the gneissic rock penetrating the schists, in their original condition probably of a basic eruptive, and the latter also cutting the contiguous gneissic masses. These rocks are both also cut by basic dikes of later origin (pp. 290–296).

The lowest rock seen was described as gneiss; but at the same time the gneissic structure was found to not always prevail. This lowest rock, which was accepted as Laurentian, is not only sometimes massive, but it is either granite or syenite, i. e. the dark mineral is sometimes mica and sometimes hornblende, or both at the same time.

The granites and syenites were not all put into the same stratigraphic horizon. The "fundamental gneiss," which manifestly lay below the mica-schist horizon, occupies a distinctly marked stratigraphic place. Such is that seen at the northwest end of Vermilion lake. Not to mention the red syenite which is intimately associated with the gabbro, and is certainly of the same date, in its present condition, as the gabbro, a further distinction was introduced by which the rock of the Giant's range, where the range consists of a narrow and abrupt ridge of granite rock, is separated from the age of the Laurentian, and is shown to be the result of local change in some bedded sediments probably later than the Laurentian — a change that, beginning with a partial crystallization of the beds *in situ* by which fine-grained, red-weathering syenite, not distinctly individualized as to its mineral constituents, was produced, and continued, under the action of the same dynamic forces, whatever they are, till a perfect fusion and subsequent extrusion and re-crystallization of the same matter were enacted. This was discussed and roughly illustrated on pp. 347 and 349. Some of the distinct observations are recorded on pp. 352 and 353. The cause of this fusion of the sedimentaries was supposed to be the great eruptive epoch of the gabbro; and this red syenite is made the parallel of the "red rock" of the earlier reports, the red quartz porphyry and the "palisade rock" of the lake Superior shore. The gabbro is not present, however, in all places where this fusion has resulted in extrusion of the acid molten rock, although it is nearly adjacent, or actually overlies the acid rock in many places. In the report this change in the ancient sediments is attributed to the contact of the molten gabbro on them, but there may be and probably are, many places where the extruded acid rock came from some greater depth, though yet within the super-crust, and its fusion and extrusion may not be attributed to immediate effect of contacting gabbro, but must be supposed to be only a part of a wide-spread and deep-seated metamorphic action that affected the region and culminated in extruded molten rock only along those lines where the dynamic action was most intense. Such a line of intense activity seems to be marked by the location of the narrow ridge known as the Giant's range, at least south and southwestward from Birch lake.

The sixteenth report, 1887.

The results of systematic stratigraphy contained in the sixteenth report, while varying somewhat from those of the fifteenth, in the main are concordant therewith. They were drawn from a special reconnoissance of the region of the typical Huronian, north of lake Huron, and a comparison of the results of that reconnoissance with a re-examination of the so-called Huronian of the Marquette and Gogebic iron regions of Michigan, united with previous knowledge of the region of northeastern Minnesota. In some of these results my brother and myself are not quite in concord, but these differences appertain solely to the possible parallelisms of some Michigan and Wisconsin formations with some in northern Minnesota, and on making further field examinations and research into the comparative lithology they may disappear entirely. In the following summary only those systematic results that are in harmony with the writer's convictions are stated, with some foot-notes that call attention to interpretations that are entertained by my brother.

The name Huronian, if used at all, should be applied only to the strata that were first included under the term when it was introduced and defined, and to their stratigraphic equivalents in other parts of the country. The English geologists do not recognize the formation in the British Isles, but include the strata that are presumably included under this term by the Canadian geologists, in the term Lower Cambrian, which embraces the Primordial fauna. The definition of the Huronian which has been accepted is that of Logan, based mainly on the observations of Murray in the region north of lake Huron, republished in the "Geology of Canada," 1863.* With this understanding the sixteenth report shows an effort to trace the original Huronian formation through Michigan and Wisconsin to Minnesota, and to ascertain the Minnesota equivalents of some of the minor divisions of the crystalline rocks older than the Huronian.

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*It is well known that the Canadian geologists have later extended the term widely beyond its typical region, and amplified its significance, so as to make it cover all the schists down to the gneisses of the Laurentian. Recently, however, Dr. A. C. Lawson has separated these schists from the proper Huronian, and has designated a part of them Keewatin. "Report on the geology of the lake of the Woods region." An. Rep. 1885, Can. Sur.

The Huronian, in its typical locality, embraces three principal members.

1. Red and white quartzyte, granular and sometimes conglomeritic.
2. Slate and gray quartzyte, sometimes conglomeritic, making a conglomeritic slate, or "slate conglomerate."
3. Very fine-grained gray or white quartzyte.

These are fragmental, and show every character that is known to indicate sedimentary origin. The formation embraces no mica-hornblendic schists, no sericitic schists, no typical graywackes, no gneiss or gneissic rock. The beds dip with uniformity toward the south, are cut by doleritic intrusions and are overlain by the products of such eruption. They lie unconformably on a "gneiss" which is admitted to belong to the Laurentian, from which the formation received many and conspicuous boulders. The thickness of the formation may be as great as ten thousand feet. There is considerable evidence to show that the upper quartzyte lies unconformably on the slates and slaty conglomerate, although there was no actual observation of such a relation. The formation also embraces red felsytes and some gray gabbro.

Broadly parallelized this is recognized at once as the Animike of Minnesota, embracing in that term the gabbro and "red rock" Mesabi, the Pewabic quartzyte,* the black slates and gray quartzytes and the Ogishke conglomerate. At the same time the upper quartzyte is provisionally parallelized with the true New York Potsdam sandstone quartzyte.** This quartzyte with its Potsdam characters, including a primordial fauna, is found to exhibit characteristic outcrops in Barron county, Wisconsin, southern Minnesota, southeastern Dakota as well as in New York, and in Vermont where it early received the designation "granular quartz."

Subsequently this unconformable quartzyte was traced through the Marquette iron region of Michigan, and its unconformity on the iron-bearing rocks was observed and figured at two points.

The iron-ore rocks of the region of Marquette are, in the 16th report, made the parallel of those of Vermilion lake in Minnesota, and hence a part of the Keewatin which underlies unconformably the Huronian. The dioritic group and the gold-bearing serpentine group of Dr. C. Rominger are, together, made the equivalent of the sericitic series (i.e., the Keewatin) of Minnesota, embracing in that the schists that hold the jaspilyte at Tower, the conglomerate of Stuntz island, the Kawasachong rock, the green conglomerates at Ely, the lower portion of the great conglomerate at Ogishke Muncie lake,[*] the dolomyte at Ogishke Muncie lake, and the "greenstone belt," in general, of the map accompanying the 15th report. This series of rocks is not found in the area of the original Huronian.

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* For a description of the Pewabic quartzyte see p. 86, 16th report.

** Compare "A great primordial quartzyte." American Geologist, March, 1888.

The iron-bearing rocks of the Penokee-Gogebic range of Michigan and Wisconsin, however, are not considered to be in the same formation as those at Vermilion lake. They are made to be the equivalent of the slates and iron-bearing rocks of the Animike of Minnesota, and hence of the true Huronian. The evidence of this need not be repeated at this place, although it is not expressed fully in the report here summarized. It will be given more fully in a later chapter in this report.[†]

An important point was reached, in the 16th report (pp. 97-98), in the separation of the Ogishke conglomerate from the greenstone agglomerate on which in some places it must lie unconformably. They seem to have both been affected by the gabbro epoch of disturbance, and the gabbro was found in different localities to lie on the gently inclined strata of one and the nearly vertical strata of the other.

Facts confirmatory of the origination of crystalline acid eruptive rock, both *in situ* and in form of overflow, from fragmental strata, as before reported in the 15th report, are given again on pp. 104–108 in the 16th. These fragmental strata seem to be some part of the Keewatin, and were originally conglomeritic.

Bearing on the question of the age of the gabbro-red-rock flood, which is taken by the Wisconsin geologists to be the base of the Kewenawan, or Cupriferous, of the lake Superior region, some facts were reported in the 16th report (pp. 85, 87, 88) which show that the gabbro began to be extruded during the deposition of the great quartzyte which overlies the Animike, and that the great mass of the gabbro is of not much later date, i. e., of the age of the primordial quartzyte of the Northwest which is considered to be of the age of the Potsdam of New York and the "Granular Quartz" of the Taconic.

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[*] My brother, however, regards the Keewatin schists as bearing no relation to the Serpentine group of Rominger. See p. 343.

[†] On the other hand my brother is disposed to regard the Gogebic ore-bearing rocks as having about the same horizon as those at Marquette, which he does not admit within the Huronian; (pp. 188 and 194). The Penokee rocks, however, he would make Huronian.

2. THE VARIOUS STEPS OF PROGRESS.

If we revert now to the list of problems that were unsolved touching the crystalline rocks of the state in 1872, when this investigation began, we shall see that, by the aid of the geologists of Wisconsin and Michigan, great advance has been made in settling some of the questions then pending.

1. The uncertainty respecting the possibility of making a stratigraphical subdivision of the "Azoic" of Foster and Whitney, or the "Archæan" of J. D. Dana, exists no longer. There is a more or less extended subdivision, sometimes into only two parts but more frequently into three or more, which is accepted not only by the geologists of the Northwest but by geologists who are at work on this group of rocks throughout America and Europe. So far as Minnesota is concerned this subdivision can be carried still further, and six members of the "Azoic" (if the Huronian be included in it) can be described which maintain a constancy of character and stratigraphic position extending into Wisconsin, Michigan and Canada, such that they have to have individual description.

2. The terms Huronian and Laurentian were applied to two of these parts by the Canadian geologists. Though misunderstood, by reason of the contradictory and varied definitions that have been given these terms by geologists later than the descriptions of Murray and Logan, when they are compared with the typical regions in Canada they are found to have definite and easily recognizable application to stratigraphical horizons which are extended over the whole Northwest, if not over the world.

The Huronian formation is satisfactorily established as the equivalent of the Lower Cambrian of Sedgwick. This conclusion is not wrought out in any of the annual reports of the Minnesota survey. It is an inference, however, from two other facts which have been indicated in the foregoing synopsis of the Minnesota annual reports, and it has been urged elsewhere by the writer. These two facts when united constitute a demonstration as incontestable as any mathematical formula, viz.:

The Lower Cambrian is equal to the Taconic,
The Huronian is equal to the Taconic,
ergo
The Lower Cambrian is equal to the Huronian.

We shall not stop here to bring forward anew the evidences on which these premises are based, but will proceed to mention other advances that have been made since 1872 in a knowledge of the crystalline rocks of the Northwest.*

4. The foregoing conclusion involves premises which themselves were doubtful in 1872, and which, in the opinion of the writer, are sufficiently established to be admitted as truths. The first is, that the Huronian of the Canadian geologists is the same formation which was named Taconic by Dr. Emmons of the New York geological survey. It makes no difference except in the greater difficulty involved in making this fact appear to the satisfaction of geologists, how long and how honestly the Huronian has been sustained by competent geologists, nor how long the Taconic has been as honestly ignored by the majority of opinion; if these names were actually applied to the same formation, the sooner it be acknowledged by American geologists and the proper adjustment be made in nomenclature, the better it will be for American geology and the credit of American geologists.

5. The other doubtful premise involved in the conclusion (3) above mentioned, can be considered doubtful no longer, viz.: The Lower Cambrian is the equivalent of the Taconic. There are some who bring trifling objections to the actuality of the Taconic at the horizon of the Lower Cambrian, but the evidence is so strong and is based on so large a mass of concurrent fact and testimony that it is practically demonstrated.

6. The Animike rocks having been shown, first by Prof. R. D. Irving, and subsequently by the Minnesota survey, to be the

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* On the identity of the Lower Cambrian with the Taconic, see the writer's papers:

Notes on classification and nomenclature. *Amer. Naturalist*, August, 1887.

Some objections to the term Taconic considered. *Amer. Geologist*, March, 1888.

A great primordial quartzyte. *Amer. Geologist*, March, 1888.

Report of the American sub-committee on the Lower Paleozoic, to the London International Congress of Geologists. *Amer. Geologist*, September, 1888; also the report of the Congress.

The same view has long been held by Jules Marcou, J. Barrande, and by Dr. E. Emmons, and by other geologists later. Compare S. A. Miller. The Taconic system as established by Emmons and the laws of nomenclature applicable to it. *Amer. Geologist*, April, 1888. Also A. Winchell. The Taconic question. *Amer. Geologist*, June, 1888. C. D. Walcott. *Bulletin No. 30, U. S. Geol. Survey*, and *Amer. Jour. Sci.*, March, April and May, 1888. Mr. Marcou's principal papers are: The Taconic system, and its position in stratigraphic geology. *Proc. Am. Acad. Arts and Sci.*, Vol. XII, 1884. American geological classification and nomenclature, May, 1888.

On the identity of the Huronian with the Taconic; see, The crystalline rocks of the Northwest, N. H. Winchell, vice-presidential address, A. A. A. S., 1884. At a much earlier date the same view was held by E. Emmons, and by J. Marcou. It has also been stated by A. Winchell in the 16th report, p. 170.

equivalent of the original Huronian, it follows that they are also the equivalent of the Taconic and of the Lower Cambrian, and belong within the primordial zone of Barrande, although the distinctive fauna of the primordial has not yet been found in the typical Animike region.

7. The Laurentian rocks, of the Canadian geologists, are divisible into three parts, having different genesis and age. This fact has not been recognized, so far as the writer is aware, except by the Minnesota survey. These three classes of Laurentian (because they have all been so styled by the Canadian geologists) have been separately recognized by different geologists, both Canadian and American, and conflicting inferences have been drawn from them, which have tended to unsettle the whole foundation on which the Laurentian rests. Some have seen valid reasons for supposing the Laurentian older than the "Huronian" and conformable with it, and have given the details of the facts which show it. But others have seen another class of evidence, equally valid, that tends to make the "Laurentian" rocks of eruptive origin and more recent than the Huronian. And again some similar syenitic rocks have been described by the Minnesota survey* mingled in great masses and areas with the Mesabi gabbro. These three classes have been observed and described in Minnesota, as rehearsed in the foregoing synopsis of the Minnesota work. It is believed that these distinctions are fundamental, and that they extend throughout the Northwest, and that when they are recognized generally by observers many of the apparent discrepances that have been noted respecting the Laurentian will disappear.

8. The Laurentian, then, is easily divisible into three parts, but it would not be claimed, probably, by any one, that the same stratigraphic term should be applied to them, and the question may fairly be considered to which of them does it belong.

Besides the subdivision of the "Laurentian" into three parts, as above noted, a different separation has been recognized by some, viz.: into *gneiss* and *crystalline schists*, on the assumption that the original Laurentian contained such schists. This is a necessary and valid subdivision, from that point of view, and was adopted by Prof. R. D. Irving. It is also approved by my brother, A. Winchell, in the 16th report.

9. The "Laurentian" is therefore partly the result of change

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*It seems very likely that this so-called Laurentian has also been described in Canada in the regions where the eruptive gabbro is found.

in situ from old sedimentary strata of Laurentian age, and partly the result of eruptive forces which have caused an extrusion and partial overflow over later sedimentary strata of some of the fused material of the same old strata. Such extrusion has taken place at least at two epochs, and the later one is of the age of the gabbro and may have not risen from so great a depth as the former.

10. For reasons which have been mentioned elsewhere* it appears that by hydro-thermal fusion the deep-seated sediments of the super-crust became crystalline: also that the normal super-crust is necessarily acidic: also that any eruption from the fused portions of the super-crust would not only produce an acid eruptive rock when cooled, but that in the later history of the earth (Cretaceous and Tertiary) such acid extrusions could rarely if ever reach the surface of the earth, but would form laccolites amongst the strata overlying the zone of complete fluidity.

3. THE RESULTS OF THE INVESTIGATION SO FAR AS THEY APPEAR AT PRESENT.

If these steps of progress be applied specifically to the crystalline rocks of the state, we shall find some such history as the following delineated therein with greater or less distinctness.

The Laurentian age.

The name Laurentian is applied here essentially to the "fundamental gneiss." It does not go so far back as to include the first rigid primeval crust that formed from cooling nor so far subsequent to it as to embrace any noteworthy strata of basic minerals that might indicate a formation different in nature, or manner of genesis from the gneiss. In other words it does not include the "crystalline schists." The rock is essentially gneiss, either granitic or syenitic. It resulted from the fusion and recrystallization of the earliest sediments. It occupied a long period, and one that must have been marked by profound quiet, and by uniform conditions. The siliceous accumulations that were the product of oceanic waves and beaches, began in the shoal parts of the ocean and widened as the dry land increased in area, forming the nuclei of the continents. These sediments must have been siliceous, because such only would remain undissolved by the hot and finally alkaline waters of the ocean. When they accumulated to a great thickness they were buried under iments of another kind, those of the "crystalline schists," rking the opening of another epoch in geological time. erever they had been raised above the level of the ocean y constituted the only land areas that existed, and perhaps this day those areas, or some of them, have not again been merged.

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*Compare "Some thoughts on eruptive rocks with special reference to those of Minnesota." N. H. Winchell, A. A. A. S., 1888.

Distribution of the Laurentian in Minnesota. A large part of nnesota is occupied by this fundamental gneiss. It is not to supposed that all the area now occupied at the surface by is gneiss, was originally the land area of the state at the time the close of the Laurentian age. The lapse of time has ought the earth through many vicissitudes. The original area the Laurentian has been increased at the surface by the growth the continent which has steadily expanded and risen higher ove the ocean's level. As the later strata have successively en elevated to dry land they have been subjected to such structive action, first of the ocean's beach-line, and afterward the agency of the atmosphere, that they have been worn back d have uncovered the gneiss over extensive areas where it was first hid.

In Minnesota this gneiss must have extended diagonally across e state from N. E. to S. W., crossing the Mississippi river d occupying the region of its headwaters about Itasca lake, d including the region of the upper waters of the Minnesota er. There may be spots, or considerable areas, within this iginal gneissic belt, where by subsequent deep-seated hydro-ermal fusion these primitive Laurentian sediments have been ndered plastic and then fluid, and have by pressure been ex-uded through fissures in the crust to the surface, or have been covered as laccolites by the destruction of the overlying strata; t wherever these exist they are presumed to show their later igin by their non-gneissic structure, or by their overlying some ter sedimentary strata. The distinction, however, between e eruptive condition of the fused Laurentian sediments, and e primitive sediments that have been converted *in situ* into the ndamental gneiss is one that requires more study before it can defined. That both conditions exist there is no question; at they can always be distinguished is not to be affirmed.

This Laurentian gneiss is represented by the Basswood lake d perhaps the Saganaga lake granites, and probably by the eisses that are found in the Minnesota valley from near Morton northwest to Big Stone lake. Northwestwardly from the Basswood area are others of similar gneiss, which have their extension northeast and southwest, nearly parallel with the extension of the other areas. Indeed the geographic distribution, no less than the geological facts that are observed in the field, favors the supposition that these alternating gneissic belts in the northwestern part of the state show either simply the denuded crests of stratigraphic anticlinals or of upward swells of the iso-hydrothermal fusion that has affected the ancient Laurentian sediments. This question is one that requires further investigation. It is referred to again under the head "Problems still unsolved."

Eruptive Syenite. Closely associated with these belts of fundamental gneiss are areas of massive eruptive syenite. It is a fortunate circumstance that the apex of one of the anticlinals of the gneiss runs near the present natural surface, and its manner of transition from sedimentary to crystalline rock can be observed. It would be more consistent with the tilted, even vertical, portion of the beds at the points where this transition has been observed, to suppose the change was due to the varying depths at which planes of equal hydro-thermal fusion ran below the surface at the time it took place, than to suppose it is due to an actual undulation in successive anticlinals of the same stratigraphic horizon. This favorable apex for observing the genesis of gneiss is in the line of the gneissic belt that runs southwestward from the west end of Gunflint lake, and which apparently is continued in the form of erupted syenite in the Giant's range southwestward from Birch lake. It was observed particularly on the Kawishiwi river (15th report, p. 353) and about the south shore of lake Kekekebic (15th report, p. 367; 16th report, p. 103–107). Whether that part of this gneissic belt which is referable directly to a change *in situ* in sedimentary materials be of the same age, i. e., on the same stratigraphic horizon within those sediments, as others that exist further northwest or not, they are here considered to belong to the Laurentian age in so far as they have not been entirely fused and extruded in a liquid state so as to form erupted rock.

It has already been remarked that the erupted massive form of the acid Laurentian is closely associated geographically with the gneissic. Whether they were of contemporaneous origin is not certain. But that the erupted condition was in some cases produced subsequent to the age of the "crystalline schists" is evident from the fact that such rock replaces and cuts those schists. This fact has been recorded many times. One of the most remarkable replacements of the dark schists by the bodily transference of syenite is seen north of Gunflint lake, and is described and mapped by Mr. Grant in this (17th) report. That some other areas of syenite were of considerably later date, possibly so late as to have flowed over the Keewatin (greenish, or hydro-mica) schists is indicated by observations made by H. V. Winchell along the Giant's range southwest from Birch lake, and by myself on the shores of Kekekebic lake, where a conglomerate porphyroidal rock passes into gneiss, and directly overlies some Keewatin schists. That other of the erupted syenites of the state are as late as the gabbro, and hence overlie the Animike, is shown not only by the syenites associated in mutually intermolten sheets with the eruptive gabbro that overlie the Animike, but also by the observations made at the Aurora mine in Michigan (16th report, pp. 58 and 187). This is indicated also by the observations and conclusions of Maj. T. B. Brooks and by Dr. C. Rominger in respect to the age of some of the granite rocks of Michigan.*

The age of the Vermilion schists, or "crystalline schists."

It has been remarked† that the mineralogical difference bebetween the gneisses and the dark "crystalline schists" is so great that it is allowable to attribute to the latter a different method of genesis, one sufficiently distinct to have introduced a different geological time or age. This fact was recognized in 1886, and the rocks that mark the opening and continuance of this new epoch of time were separated under the name "Vermilion group." A similar series of schists had been noted by Lawson in the region of the Lake of the Woods in 1885,‡ but, while separated by him into two parts, viz., "Schistose hornblende rocks," and "mica schists," had been by him embraced under the general term of "Keewatin series," and considered as the basal part of that series, and assigned to extra-Laurentian time. Subsequently Mr. Lawson identified the mica-schist group

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*T. B. Brooks, on the youngest Huronian rocks south of lake Superior. *Am. Jour. Sci.* (3), xi, 206.
Carl Rominger. *Geological Survey of Michigan*, Vol. IV, p. 22.

†A. Winchell.

‡Report on the geology of the Lake of the Woods region. Report C. C. of the Canadian survey, 1885, pp. 37, 54.

and the basal portions of it (the hornblendic schists and the eruptive features that characterize the horizon) in the region of Rainy lake, and has given a description and a name for the mica schists. (*Am. Jour. Sci.* June, 1887, p. 473). He includes the mica schists under the term *Coutchiching*, and supposes the changed eruptive rocks which intervene geographically between them and the belt of Laurentian gneiss lying next north (along the northern shores of the southern part of Rainy lake) to be of later date than the schists.

A similar group of mica and hornblendic schists had been noted in Michigan by Brooks and in Wisconsin by Irving and been placed in the Laurentian. Rominger included the same in his "granitic group" (Geol. Mich. Vol. IV, p. 17–18). Higher in the stratigraphic series, i. e., between the magnesian soft schists and the gneiss and gabbro of the post-Huronian rocks,* another formation of mica schist was observed by them, which they placed near the summit of the "Huronian." They gave neither of these any special designation. In New Hampshire the "Montalban series" is one essentially of mica schists, but† whether it can be parallelized with either of the northwestern horizons of mica schist is a question which the future alone will be able to answer.

Hornblende schists converted to mica schists. To the writer, however, the micaceous and the hornblendic characters seem to be so blended, and the one so frequently substituted for the other, that the two parts described by Mr. Lawson appear to be only phases of the same set of rocks. The hornblendic condition, as schists, is without doubt the fundamental and primary one; and that one is found nearest the gneiss of the Laurentian. Hornblende is easily converted into biotite; biotite has so close relations with muscovite that it is sometimes twinned with it in the same crystal; muscovite is replaced both across the bedding and along the strike by hydro-mica or pearl-glimmer, and the last passes insensibly into the talcoid "Keewatin stuff"‡ of the Keewatin series. There is a conformable succession, both genetico-mineralogical and stratigraphical, from the hornblende schist through the mica schist into the hydro-mica schist, by which these are bound fundamentally into one group, as placed by

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* Geology of Wisconsin, Vol. III, 1873–79, pp. 93, 145, and table between pages 136 and 137.

† Geology of New Hampshire. C. H. Hitchcock, Vol. II, p. 112.

‡ A. Winchell. Sixteenth report, p. 343.

Lawson, and no other sort of transition is known or indicated. On the other hand, bearing in mind the strong mineralogical break, or contrast, between the gneiss and the hornblende rock, there is not so close a mineral relationship with the Laurentian. There is also, in some places, as profound a stratigraphic break and non-agreement. This is shown in numerous descriptions and illustrations not only of Mr. Lawson, but also by the 15th and 16th reports of the Minnesota survey. Mr. Lawson emphasizes this fact by a remarkable inference, viz., that the Laurentian is eruptive and of later date than the Keewatin schists. Not to dwell on this inference at this time it is sufficient to call attention to it to show the probability of a plane of profound discontinuity between the Laurentian, as here defined, and the Vermilion group.*

Nature of the transition from the Laurentian to the Vermilion. As to the nature of the dynamic agent which introduced this change in the crystalline rocks at this horizon, it is indicated by the nature of the rocks themselves. Primarily they are characterized by the minerals that constitute a basic eruptive. They are found to exist at first as structureless knobs of dioryte or doleryte. These lie nearest the gneiss (15th report, p. 330). They are flanked by basic rocks of various modifications, among which hornblende schist is predominant. Gradually, on receding from these black knobs, a sedimentary structure becomes apparent, and the hornblende is replaced partially or wholly by black mica. At last the rock is changed to a nicely stratified mica schist which at first is perhaps very dark-colored and firm, with little free silica, and subsequently, with an increase of silica, is striped with distinct strata of granular silica. As the dark mica still further fades out the mass is converted to a fine granulyte or quartzyte, or a light-colored mica takes its place and the whole passes into sericitic schist or graywacke.

It is not always the case that all evidence of molten condition is wanting at this horizon of transition from the gneiss. But it is very slight at most of the sections which have been described.* If, however, but a single unquestioned occurrence of eruptive conditions be found at this point it is sufficient to warrant the hypothetical introduction of a general eruptive epoch, so widespread as to constitute a change from one system of rocks to another. No one can read the descriptions given by Mr. Lawson, or some of those contained in the 15th and 16th reports of the Minnesota survey, without recognizing not only one point but numerous points where eruptive characters are stamped at this horizon not only on the basic rocks of the Vermilion but also on those of the acidic "Laurentian." They mutually interpenetrate each other in the form of transverse dykes and mutually embrace isolated fragments separated each from the other. It seems to be abundantly demonstrated that some sort of dynamic change was introduced. The only inference that such a demonstration points to, in the light both of the contrasted lithology and the interrupted stratigraphy, is that of volcanic action.

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* Compare, A. Winchell; 15th Report, pp. 41, 43, 87, 97, 180: H.V.Winchell; 16th Report, pp. 407, 416, 417, 419, 455, 456: N. H. Winchell; 15th Report, pp. 291, 338, 349; 16th Report, pp. 76–77: M. E. Wadsworth; 15th Report, p. 331.

* Compare, however, Lawson, Can. Rep. 1885. C. C. p. 41; Am. Jour. Sci. June, 1887, p. 477.

Having now fairly stated the nature of the change which is presumed to set off the Vermilion rocks from the Laurentian, it is necessary to consider, further, whether the gradual and conformable conversion of the Laurentian beds into the Vermilion, such as has been seen at many places, and which indeed is the most frequent manner of transition,* is consistent with the hypothesis of an epoch of eruption. It should be remembered that the beds do not now hold the position they had when they were deposited. They stand now nearly vertical. While this upturning facilitates the deciphering of their history, it has been accompanied by such changes in the crystalline condition of their elements that a screen that partially conceals their history has been thrown over them all; yet through this screen can be seen the outlines of their historic and dynamic genesis.

Admitting the actuality of a period of volcanic action at the opening of the Vermilion age, it is evident that the eruptions would take place only at centers of intensity of pressure. Once located, such vents would for longer or shorter periods continue to send forth the eruptive matter. In the presence of the almost world-covering ocean these materials would be at once distributed, dissolved, deposited, in the same manner as sediments at the present day, excepting only that probably the solvent power of the ocean's waters was greater than at the present time. The former sediments having been almost wholly of an acid nature,† such that when crystallized again they constitute the fundamental gneiss, they must have been accumulated slowly. But on the advent of this new supply of material, which is so rapid that it can not all be worked over by the ocean so as to be dissolved and its alkaline elements extracted, the erupted materials are thrown down in the condition of stratified sediments, retaining to a great extent their chemical composition. In the periods of comparative quiet these basic materials are interbedded with more siliceous materials, such alternations taking place as long as the supply of basic material is intermittent. Thus might be formed a great series of strata, surrounding the volcanic centre, thousands of feet in thickness, which would be made up of variously interstratified or mixed siliceous and basic sediments. Sometimes there would be intrusions of purely basic doleritic rock among these sediments, at different horizons, due to the bodily overflow of sheets of lava among the sediments,* in a manner similar to the interbedding of trap rock in the Kewenawan at a later date. In other places these eruptions might take place somewhat later, involving in fracture, upheaval and mixing the last made strata in forms of various fragments and breccia in the molten rock that escaped.** Such an epoch of disturbance, sufficient in its force to cause the outflow of basic rock from a deep source, would probably be sufficient to fuse and cause the outflow of some of the sedimentary rock that already had been formed. Thus the basic and acid rock would mutually interpenetrate, and a series of fractures which would be filled by the injection of any fused material that was adjacent, would be perpetuated to the remotest time in the form of transverse and more or less concordant dikes and by breccias composed of the two rocks.

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* Mr. A. C. Lawson has described such in his report on the region of the Lake of the Woods pp. 73, 76, 83. See also A. Winchell; 15th Report, pp. 97, 101, 178; 16th Report, pp. 264: H. V Winchell; 16th Report, pp. 405, 415, *et passim*: N. H. Winchell; 15th Report, pp. 296, 298; 16th Report, pp. 69, 70, 76.

† That is, containing over 60 p. c. of silica.

It is manifest, therefore, that the supposition of the advent of a characteristically eruptive era, closing the quiet Laurentian sedimentary age, will account for both an unconformable and a conformable transition, such as are seen, from the Laurentian to the Vermilion.

Effect of hydrothermal fusion. It is necessary, before proceeding to the consideration of the next age, to call attention to another great fact in connection with the history of the Vermilion. Nothing is more evident to the geologist who carefully inspects the Laurentian and Vermilion strata, than that they have had, in some respects, a common experience. This, however, is subsequent to the date of the origination of the rock masses, and has had a tendency to so unify their mineral characters as to blend them, in the opinion of some geologists, indissolubly into one system. They contain, excepting the eruptive diabases, etc., at the base of the Vermilion,—essentially the same mineral components; but those components are differently distributed and exist in very different proportions. These minerals are interlocked with each other in crystalline contact. It is very difficult to affirm, in many places, any fragmental grains. They lie in such continued parallelism in long sheets that there is no natural agent except sedimentation that can be appealed to to account for the stratification. The strata do not consist of individual minerals, that is, any single stratum may contain several minerals, but they change in relatively proportionate amounts in a direction across the strike, and this slow change, which on weathering brings out either light or dark bands, is so gradual that some of the strata or some parts of the strata, can not be separated from the others by any accepted designations. Within the same band the gneissose aggregation changes to a schistose. While in a general way it may be said that the mica schist alternates with what Mr. Lawson has conceived to be a series of thin gneissic dykes in as many sedimentary beds of mica schist, it is equally true, and equally as evident on inspection, that the schist fades out across the beds, into gneiss by a change in the relative amounts of the constituent minerals. It is very certain that if the schist, in such places, be attributable to sedimentary origin the gneiss is equally so.* Indeed often within the gneiss itself are distinguishable narrow, parallel belts of varying color and lithology at some distance from the horizon at which the general gneiss mass began, which must be attributed, as certainly to the same cause as in the schist. These only lack the dark coloring minerals to show their nature more evidently, and their similarity of origin with those unquestioned parallel belts that mark the schist.

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* H. V. Winchell seems to have encountered such in that great extension of the Vermilion northwestward from Vermilion lake to Rainy lake. See, specially, 16th report, p. 425.

** See the 15th report, p. 333, and p. 337.

This crystallizing and unifying of the mineral characters must have taken place in these strata while they were yet buried at considerable depth below the surface, or at least at such a depth that they were affected simultaneously by hydro-thermal fusion.

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* Compare H. Reusch, *Boemmeloen og Karmoen med omgivelser geologisk beskrevne* (English summary), p. 389, 1888.

Whether before, during, or subsequent to the process of upturning which has brought them both to a vertical attitude, it is not necessary here to inquire. Indeed, this is yet one of the "unsettled problems."

The Keewatin schists.

This term is here used in a sense somewhat restricted from that in which Mr. Lawson first applied it, inasmuch as it does not include the crystalline schists. This change, however, will doubtless be considered allowable, since Mr. Lawson himself seems to have separated the original group into two series by the application of a distinctive term to the mica schists — the Coutchiching.*

Conformable transition from the Vermilion. It has already been stated that structurally there is a conformable transition from the Vermilion to the Keewatin. This has been found to be the case without exception, so far as the Minnesota survey is concerned, and it seems not to be contradicted by any facts reported by Mr. Lawson. Indeed, so far as Mr. Lawson has reported any facts,** they tend to harmony with the facts and conclusions of this survey. Very favorable opportunities have been afforded for the minute inspection of these beds where they pass to the Vermilion, in many places, and they are reported in the fifteenth and sixteenth reports. There have been five different geologists, engaged within the last three years by the Minnesota survey, who have made independent examinations at this horizon of transition, and at separate places, and in every instance they have reported a gradual and conformable transition from the Vermilion to the Keewatin.

There is also a corresponding gradual change in the crystalline condition and the composition of the beds. While the materials are referable very largely to the same source as the materials of the Vermilion, there is an increase of quartz and a loss of mica in ascending in the strata. The schists become sericitic, or chloritic, or argillitic, and are interbedded with graywackes and agglomerates; the last prevail near the top and indeed seem to have introduced the marked eruptive characters that distinguish the next formation.

Nature of the Keewatin rocks. It appears, from the character of the rocks of the Keewatin, that active volcanic vents existed throughout the whole period, and that the ejectamenta were received in the waters of the surrounding sea. The strata contain much silica, in rounded grains and pebbles, indicating the waning of the volcanic supply and the influx of sedimentation similar to that accumlated during the Laurentian. There are dykes and various diabasic rocks associated with the Keewatin strata, some cutting transversely and some nearly, but not quite, parallel with the strike, some of which are certainly of a later date, but of which some seem to belong to the age of the Keewatin. Whether any of these have any possibly traceable connection with some of the old volcanic vents, existing within Keewatin time it is not now possible to state, but it is very likely that such connections will ultimately be established. At any rate the Keewatin closed by a renewal of active eruption as profound in its energy and its effect on the pre-existing strata as that which marked the close of the Laurentian. In the vicinity of Tower and thence eastward the rocks that evince this epoch of volcanic eruption have been insepcted at many places, and they are described with accompanying illustrations showing the crumpled and faulted condition of the earlier aqueous strata, in the fifteenth annual report (pp. 223–275). The rocks which resulted from this renewal of igneous forces form a conspicuous series and they have been traced almost continuously from Tower to the vicinity of Gunflint lake where they pass below the Animike. They show the same confused blending of stratified with massive rock as has been mentioned at the base of the Vermilion. In many places they constitute hills that rise one hundred to three hundred feet above the adjoining lowland levels, and consist of a greenstone that exhibits all the outward characters of diabase or doleryte. At many places this greenstone is agglomeritic, some of the stones showing, by a periphery of amygdaloidal structure, that they were immersed in a magma that differed from them in the amount of contained heat, or in their capacity for receiving and transmitting heat. The massive structure sometimes embraces large fragments rent from beds of stratified structure, and the massive structure itself sometimes acquires a faint lining and then a distinct banding which cannot be attributed to any other known agent than sedimentary action. The greenstone is frequently jointed in a columnar manner, forming basalt, in which cases it seems necessary to regard it as a primary basic eruptive. All the other modifications and exceptions which this greenstone exhibits causing a departure from the characters of a normal basic eruptive are to be referred to the action of the ocean on the erupted materials, or on the local rupture of the pre-existing strata and the mingling of the fragments with the new materials. It is evident that in some places these fragments would be gently covered and inclosed by new sedimentation and such instances are shown on the south shore of Vermilion ake) producing the curious alternations of breccias and parallel strata, all of the same kind of rock, which have excited the wonder of more than one geologist. It is equally evident that in other places these fragments would be covered by an overflow of erupted material that did not come into conact with the ocean's distributing action, and there would result a basalt containing angular masses of fragmental strata. It has been observed that apparently the most massive rocks of his epoch change by weathering into a green chlorite or even a sericitic schist, when they occupy the lower levels and come nto contact with water, or where they are subjected to unshelered exposure to alternating frosts and moisture. In this case he original rock shows, sometimes, a sedimentary banding, and he schistosity that results may or may not coincide with the direction of this banding. Throughout nearly all the region where this greenstone prevails, the schistosity has a prevalent direction northeastwardly, and that is also the direction of the general strike of all the sedimentary rocks; but there are exceptions in the case of the sedimentary strike, which are more numerous and extensive than any that have been found in the direction of the schistosity. The ease with which this schistose structure is developed on weathering, seems to vary with the composition of the rock, or at least with its original structure. Where the greenstone is evidently a true eruptive basalt which has never been subjected to the distributing action of sedimentation the schistose structure is faint, or is wanting, and rounded knobs of structureless massive rock rise above the general level of the country. When there is an intimation of the primeval action of water on the constituents of the rock at the time of their deposition, evinced either by the presence of siliceous grains, the inclosure of fragments of stratified masses, a generally lighter green color in the whole mass, or in an indistinct banding like sedimentary structure, the schistose structure is more quickly developed.

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* Am. Jour. Sci., June, 1887, p. 477.

** Am. Jour., June, 1887, p. 477.

Vermilion iron ores. The Keewatin is the iron-bearing formation of the region of Vermilion lake. It contains the jaspilyte lodes which have been described at Tower in the 15th annual report. But it should be stated that these lodes seem to prevail in those parts of the formation that show most evidently the characters of massive and original eruptive rock, i. e., in the later portion. The knobs of jaspilyte at Tower are embraced in and penetrated by a green schist which at the surface is easily excavated, when a schist, but which at greater depth sometimes becomes a massive green rock, and which in the main must be considered an original eruptive. At short distances from the knobs, even on the slopes an evident sedimentary structure supervenes, the beds being nearly or quite vertical.

Origin of Jaspilyte. It is not necessary here to reconsider fully the question of the origin of the rock known as jaspilyte. Various considerations are given in the 15th report that go to show that it is of sedimentary origin, embraced as foreign masses in the green eruptive rock of the region. Much more study has since then been given to the subject, and while the facts and arguments then relied on are still valid some other problems have arisen which need to be solved in order to make the hypothesis of its sedimentary origin entirely satisfactory. They can be briefly referred to, viz.:

Why is the silica of the jaspilyte so uniformly of very fine grain, and of so uniform a grain?

Why does the jaspilyte accompany the most evidently eruptive parts of the Keewatin, and why is it not found in important masses in those parts that have plainly a sedimentary structure?

It seems quite remarkable that the jaspilyte, on the sedimentary hypothesis of its origin, should not vary perceptibly in the size of its siliceous grains. Reference is here made to the ultimate quartz grains into which it disintegrates on being long-weathered. When, in the stratified schists, some small pebbles from the jaspilyte are disseminated in the manner of sedimentation, the pebbles themselves, as constituent elements in the stratified mass, are seen to vary in size considerably, some of them being no larger than the eye of a needle, and others as large as pease, or even much larger. The same is true of pebbles of other silica, such, for instance as those of segregated or chemical silica which does not show the finely granular structure. But when these pebbles of jaspilyte are examined more closely they are found to be made up of almost microscopic quartz grains of the same size. The question refers to the size of these.

If they are the product of sedimentation, it would be in accordance with usual observation that they would have been collected and deposited under the action of varying currents and would vary in size from place to place, or from structure to structure (within certain limits) and some of them would be expected to be mingled with other sorts of sedimentary materials. Some observations have been made, indeed, which indicate the mingling of fine siliceous grains, supposed to be the same as the fine grains of the jaspilyte, with the sedimentary green schists in the vicinity of Tower,* but in these cases, and especially in the case of principal masses of jaspilyte that are mined at Tower, it is not yet sufficiently shown that the ultimate grains of which the jaspilyte consists, manifest such a variation as is here indicated. Indeed it is quite possible that all the siliceous grains that are seen disseminated through the green schists, as seen at Tower, are compound grains, derived as fragments from jaspilyte that preexisted as such, and that each one can be reduced, on examination, to the same minute granules as the jaspilyte itself. Therefore the question remains unanswered—why are the ultimate granules of the banded jaspilyte of so uniform a size, and so uniformly fine?

Again, it seems quite remarkable, on the sedimentary hypothesis of the origin of the jaspilyte, that it should be found, in its most typical forms and largest amounts, embraced in a rock which manifests the least of the characters that indicate sedimentary forces, and surrounded by rock that manifests unquestioned, or almost unquestioned, eruptive forces in its manner of origin.† This association is hard to explain except on the eruptive hypothesis for the origin of the jaspilyte. It might be said, with much reason, that in the midst of the basic eruptions, or at intervals of rest from basic eruptions, some acid eruption took place, and that the erupted matter assumed such forms, and such relations to the basic, whether in the presence of oceanic waters or on land, as the circumstances required, in just the same manner as the materials of basic eruption. To this the mineral nature of the jaspilyte is the greatest obstacle.

Name. The massive "greenstone" stage of the Keewatin has no distinctive name. It has sometimes been referred to as the

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* Fifteenth report, pp. 226-230.

† Attention has been called to the distribution of the jaspilyte masses by Mr. H. V. Winchell—*American Geologist*, January, 1889. *The diabasic schists containing the jaspilyte beds of northeastern Minnesota.*

"Kawasachong rock," since it forms the falls of that name at the mouth of the Kawishiwi river, on the south shore of Fall lake. But it is not desirable that such a name be perpetuated. *Kawishiwin* would be better, and it would be appropriate since this river runs for many miles, and some of its tributaries for many more, over rock belonging to this epoch of the Keewatin.

Parallels of the Keewatin. The writer has seen at but one place in the Northwest, outside of Minnesota, what he believes is the stratigraphic equivalent of the Keewatin. This belief rests entirely on lithological resemblance, with some general stratigraphic parallelism. In general, the groups which Dr. C. Rominger has described as "serpentine group" and "dioritic group,"* in the region of Marquette, exhibit the characters of the Keewatin. There may be, as thought by him, an essential difference between the dioritic and the serpentine groups, but their affinities are very close, and indeed nearly all the characters, in limited areas, are found in the Keewatin. The serpentine rocks may ultimately be found to consist of the old volcanic cones, now tilted to lie at an angle of 90 degrees, more or less, from the position they originally occupied, from which issued the ejectments that were consolidated to form the dioritic schist group. In that case they would fundamentally be of about the same age as those schists. However that may be, no one can read the careful description of the dioritic group by Rominger, be he familiar with the Keewatin, without being struck with the great mineralogical similarity. (See also 16th report, pp. 47–48.)

There is, however, an important evidence of this parallelism to be drawn from a comparison of the stratigraphy. In the Marquette region the mica schist group is but feebly represented, and is not at all shown by Rominger on his map of the region. It is included by him in his granitic group. But the dioritic group comes at once into contact with the granitic rocks of the "granitic group." This is shown to be interbedded sometimes with the base of the dioritic group, and the granite to be apparently produced sometimes by the fusion and extrusion of some of the beds of the dioritic, or from some of the lower strata, forming knobs and sudden enlargements of granitic rock within the schists of the dioritic group.† The same kind of indistinct, incipient crystallization as described by him has been noted at about the same horizon in the schists of the Keewatin north of

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*Geol. of Mich., Vol. IV, pp. 22, 24, 26, 27.

†Geological survey of Michigan, Vol. IV, 1881.

Gunflint lake, and between Ogishke Muncie and Kekekebic lakes, and the same gradual inter-bedded transition from the schists to a sub-granitic rock. In the same way also great overflow areas of acidic syenite or "granite" are found in connection with both.*

But the most remarkable stratigraphic coincidence is the relation of the Keewatin and the dioritic group to the overlying formation. In Minnesota it is the iron-bearing Animike, and at Marquette, it is the "iron group," of Rominger. This relation is one of unconformity. For evident reasons, which need not be elaborated here, the "iron group" of Rominger is considered to be on about the same stratigraphic horizon as his "arenaceous slate group." They are not shown by him to be distinct, although he supposes them to be separated by the "quartzyte group," and in both of them are found important bodies of ore in the Marquette district. They have the same relations to the dioritic group, as described by him, and their geographic distribution, as separately delineated on his geological map, especially when taken in connection with his geological descriptions, is inexplicable on the supposition of their separate identity.

In the light of what has been published by the Minnesota survey respecting the unconformable superposition of the Animike over the Keewatin, nothing further need be said as to that fact. But when this unconformity is extended to the Marquette region, and the iron-ore beds there so much worked are placed above that line of unconformity, it may need a concise statement of the evidence to make it appear plausible. While it is in perfect accord with the published conclusions of the Michigan and Wisconsin geologists, to put the ore-bearing rocks of those states in the "Huronian," it is not in accord with them to separate that horizon from the dioritic schists which really embrace an ore horizon of an older date, by a plane of unconformity; but under the term "Huronian" have been grouped, in one essential concordant series of strata, all the rocks of the district younger than the fundamental gneiss or the Laurentian. Later Dr. Rominger has stated that some of the granite of the district is eruptive and of later date than the associated schists. (Geol. of Mich., Vol. IV, pp. 17 and 22.)

The reader is therefore referred to the following quotations from the descriptions of Dr. Rominger of the relation of the "dioritic group" to the overlying "iron group" and "arenaceous slate group."*

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* The hematite lodes at Tower seem to have their representatives in the dioritic group of Rominger, but they have not proved productive enough to support regular mining. Such are mentioned by him on pp. 25, 27, 29, 30.

> Page 72; Speaking of the surface rock of the environs of Negaunee and Ishpeming, which belong to the "iron-ore group," he says: "The strata are in an exceedingly disturbed condition * * * These disturbed beds lie, in every instance, directly, but very often unconformably, on chlorito-hydro-micaceous schists, or on crystalline dioritic masses which are constant associates of these chloritic schists." * * * "Overlooking the extremely plicated and corrugated condition of the strata, they form, considered in their totality, a synclinal basin, hemmed in between dioritic ridges."
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> Page 76; "The discordance existing between the dioritic and the iron-bearing rock groups is obvious in the majority of natural or artificial exposures, although it often occurs that they adjoin each other in parallelism."
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> Page 82; "The ore-bearing beds in the lake Superior mine lie in a steep inclination, with northern dip directly on the diorite, or on schistose beds belonging to this group, but in other parts of the mine the strata are seen to be bent and folded repetitiously, and to dip in the most irregular way."
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> Page 83; "The deposits visibly underlie the jaspery massive rock-ledges and repose in a much corrugated condition on the schists of the diorite group."
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> Page 86; "In the abandoned pits of the old Tilden mine, and in several neighboring natural exposures, the ore-formation is found to repose on the diorite, or on the schists belonging to this group, but, as it seems, always in discordance."
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> Page 108; Speaking of the "arenaceous slate group," he says: "The strata lie on the side of a diorite hill dipping under a low angle toward it in a northern direction, and a few hundred steps further east another body of these ledges lies in a slanting position on the diorite."
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> Page 114; "On the south side of the large cluster of diorite knobs, north of the New York mines, we generally see the ore-formation in direct contiguity with the diorite; but on the higher part of one of the rock bluffs another kind of stratified rock [i. e., the arenaceous slate group. N. H. W.] is found to repose on the diorite in seemingly discordant position."

These statements are sufficient to show that in the Marquette region there was a profound break, or unconformity, that separated the dioritic group from that next succeeding, as marked and as general, as that which separated the Keewatin from the Animike. The fact that it has not generally been recognized, and when so observed that its significance was not noted, may be explained by the great confusion that prevails at Marquette in all the dip and strike of the rocks, due to disturbances that involved both the older and the later terranes.

Further evidence of this parallelism is found in the fact that, in the same manner the Keewatin, and the "dioritic group" of Rominger, are unconformably overlaid by a more recent quartzyte, as will appear later in this review.

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* Geology of Michigan, Vol. IV, 1881.

Jaspilyte is in the Keewatin and the dioritic group. There is a general lithological resemblance as already noted. It will be necessary here only to call attention to one. The Keewatin contains the typical jaspilyte deposits of Minnesota—i. e. those that have chalcedonic silica as their chief characteristic and occur in curiously ribboned contorted bands or masses, alternating a hard specular hematite. Although Dr. Rominger does not employ the term *jaspilyte*, he seems to make several references to it in connection with his account of the dioritic group. Such references may be found on pp. 27, 29, and 30. In other places t seems as if the descriptions that he has recorded of the phenomena of the iron mines, all of which he supposes to be n the "iron group," and not in the dioritic group, can apply only to the dioritic group. This is true particuarly of some of those in the vicinity of Ishpeming. Dr. M. E. Wadsworth's observations and figures* seem to indicate he same. The manganesic soft hematite, and the limonitic ores, which are also "jaspery," are not believed to belong to the same formation as the hard jaspilyte-hematite, but to the overlying "iron group." It is true, however, that it is impossible, at present, to indicate fully the petrographic difference that may distinguish the jaspilyte-hematite of the Keewatin from the jaspery beds of the iron-ore group. That will be subject for further study.†

Possibility of rocks younger than the Keewatin, before the beginning of the Taconic. We have seen that the Keewatin was terminated by an increased eruptive activity, producing distinctively, in Minnesota the "greenstone range," or the Kawishiwin rocks. We have no distinct knowledge of any later sedimentary beds prior to the unconformably overlying Taconic (or Animike). There are, however, some problematical rocks that different members of the Minnesota survey have noted whose position in the stratigraphic column has not been determined. They have been designated *muscovado rocks*, and in some places they hold a position some distance south of the strike of the Kawishiwin and spread over several miles of area. It is not intended to discuss them here at any length. They may be some part of the Taconic, and it is only suggested that they may be a sedimentary formation that accumulated subsequent to the Keewatin before the submergence that brought the Taconic unconformably over it.

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* Notes on the geology of the copper and iron districts of lake Superior. *Mus. of Comp. Zoology.* Geol. Series, Vol. I.

† The reader is referred to the rock "talcose conglomerate," described by Dr. E. Hitchcock n the *Geology of Vermont*, for a probable New England representative of the Stuntz conglomerate of the Keewatin. Indeed there is great reason to suspect that the Keewatin horizon in all its features exists in the "talcose slates" of western New England.

The age of the Taconic (Animike, Huronian).

[illegible] g an interval of time passed, and what its events [illegible] ting the Kawishiwin epoch from the Taconic, it is [illegible] o state. But it is evident that there was a great [illegible] the surface of the earth, wherever this succession is [illegible] which tended to allow not only submergence of some of [illegible] re-existing land area, but such general quiet, speaking [illegible] lly, as would allow slow sedimentation, and apparently the [illegible] wth of plants and animals. The black carbonaceous shales [illegible] d slates, or in other places the graphitic character of the rocks of the Taconic, where, as on Pigeon point, they have been metamorphosed, sufficiently indicate the presence of plant life in the Taconic. In other places faint tracings of rude forms, apparently of vegetation, have been observed on the sides of some of the black slates. But of these forms none from Minnesota have been carefully examined and described.[*] Of animal remains none have been found in Minnesota that belong in the black slates, but in the quartzyte overlying, some primordial fossils have been found[†] corresponding with the fauna of the Paradoxides horizon of eastern North America, indicating, so far as this evidence goes, the age of the "Granular Quartz," and of the Red Sandrock of Vermont. This formation seems to be represented in the Rocky mountains, where the primordial fauna has been mentioned by Mr. R. G. McConnell[‡] along the line of the Canadian Pacific railroad. Still earlier Mr. C. D. Walcott described it in Nevada.[§] There is no doubt that this formation is widespread. The coincident identity of the old Taconic with the "Lower Cambrian" and the Huronian need not be discussed here, and those who believe that these represent different rock-horizons will, of course, not accept the generalized history that is here indicated. To the writer there seems to be no way to group the terranes that are found in the Northwest, subsequent to the Keewatin, belonging in that general horizon that has been accepted widely as "Huronian," except to make them the parallel of that earlier-named system which was so long studied by Dr. Ebenezer Emmons, and by him named Taconic.

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[*] Sixteenth report, pp. 78, 239.

[†] Thirteenth report, p. 65.

[‡] Geol. Sur. of Can., 1886. Rep. D., pp. 29-30. Am. Geol., January, 1889.

[§] Thirtieth bulletin, U. S. Geol. Survey.

The opening of the Taconic. So far as we know the Taconic was characterized, from New England to the Black Hills, by an epoch of increased submergence beneath the ocean. There is great reason to believe that all the earlier formations [illegible] the superior crust, had been subjected to great flexure and [illegible] before this submergence. In Minnesota the underlying beds are almost vertical, nearly everywhere, and the Taconic beds dip at angles generally less than 30°. It can hardly be supposed that throughout so great an area the subjacent strata could by any transformation be placed in verticality beneath the Taconic since the deposition of the latter, without equally disturbing the Taconic also. Indeed when such rupturing of the strata, since the deposit of the Taconic, has been observed, as in the region between Ogishke Muncie lake and Gabemichigama lake, the disturbance has involved the Taconic rocks also, and has turned them into various and excessive dip. Such exhibitions, however, are exceptional, so far as observations already made in Minnesota indicate. The Taconic strata maintain, both in Minnesota and Wisconsin, as in the Mesabi and Gogebic-Penokee ranges, a regularity of dip and strike, and a low angle of inclination which are not seen in any of the older rocks.

There is a conglomerate at the base of the Taconic. This is a fragmental, sedimentary conglomerate, embracing numerous rounded fragments from the earlier formations of the region. The lowest stratum seen in the Huronian, in the region north of lake Huron, is reputed to be a quartzyte which varies to a quartzose conglomerate, and by the accession of organic matter assumes a dark color, becoming a "slate conglomerate." In the latter form it has a wonderful development, both in Canada and in Minnesota*. It is the Ogishke conglomerate, of the Minnesota reports. It seems to be the Missasaugui quartzyte and the slaty conglomerate of the original Huronian area. This conglomerate is followed by an immense thickness of dark slaty rocks, often cherty, or flinty, frequently very dark-colored, generally siliceous, alternating with thin quartzytes, and grayish feldspathic quartzytes, all in conformable stratification, as a whole. Variously interbedded with these slates and quartzytes, from bottom to top, are beds of basic eruptive rock, and it is necessary to suppose that such eruptions must have been accompanied, in some places, by extensive disturbance and metamorphism. As a group, however, the Taconic strata sustain a u[illegible] lithology, within allowable limits of variation, [illegible] them as one great series, which experienced essen[illegible] same history over very extensive parts of America, [illegible]at respect they show the same individuality as the [illegible]n and the Vermilion, which names cover respectively the [illegible]stalline (earthy) and the crystalline schists of the North[illegible] The Taconic is essentially the Olenellus group of strata [illegible]mordial.

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* On the passage of the quartzose condition into the slaty, each being pebbly, see Logan 1863, Geology of Canada, pp. 55, 56, 594.

[illegible] *ores of the Taconic.* The Taconic is the chief-iron-[illegible]tion of the Northwest. It is the "Huronian" [illegible]e Marquette region, the Penokee-Gogebic range [illegible] the non-titanic ores of the Mesabi range in Minnesota. The writer is not familiar with the Menominee iron district in Michigan and Wisconsin, but the described characters and the parallelisms that have been claimed of the Menominee rocks by Brooks, Rominger and Irving, with those at Negaunee, sufficiently show that, as claimed by Emmons and Houghton in 1846, the Menominee rocks are also of the Taconic.* The numerous important iron-ore deposits that have long been known, and formerly extensively exploited in eastern New York and western Vermont, Massachusetts and Connecticut, embracing hematite and limonite, often manganesic, afford parallels with the iron-ore deposits of the Northwest that are here classed in the Taconic. Some of the descriptions of the ore-pits of Washington, St. Lawrence and Dutchess counties, of eastern New York, recorded by Mather and Emmons in their reports on the geology of those counties are applicable, in many respects, to those of the Penokee-Gogebic and the Mesabi ranges in the Northwest.

The Granular Quartz. As used here the term Taconic does not embrace the "Granular Quartz," of Emmons, as there is sufficient evidence, in the writer's opinion, for making that the parallel of the true Potsdam of New York state.* The chief reasons for this separation may be given.

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*Agriculture of New York, 1846, Vol. I, p. 101.

(a) *The stratigraphic relations of the Granular Quartz and the Potsdam of N. Y. are the same.* In the first place they are seen to lie unconformably on the older "granite," one on the west flank of the Green mountains, and the other on the northern and eastern flanks of the Adirondacks; and in the second place they bear the same relation to the Red sandrock of Vermont. By Dr. Emmons the Red sandrock was regarded the equivalent of the Potsdam and Calciferous sandrock, but it is described by the Canadian and Vermont geologists as Potsdam. Emmons, Logan, Hitchcock and Marcou agree in making it unconformable on the underlying slates,† but Mr. Walcott fails to find the unconformity at the point described by Marcou.‡

It seems, however, that the preponderance of evidence is in favor of such unconformity, especially when it is further considered in its agreement with observations supposed to be at the same stratigraphic horizon in the Northwest and in the Black Hills. The Potsdam is therefore here the Red sandrock, and unconformable on older slates. But by the discovery of the same fauna in the Granular Quartz and in the Red sandrock Mr. Walcott has shown that these are stratigraphically the same formation. Therefore the Granular Quartz must lie unconformably on other terranes than the "Primary" of the Green mountains.

(b) *While the fossils of the Granular Quartz are cognate with those of the Red sandrock, they are also cognate with all that have been found in the true Potsdam.* They are, however, essentially different from those of the so-called Potsdam of the Mississippi valley. This need not be amplified. It is based on one of the cardinal distinctions that subdivide the primordial fauna.

(c) *The Red sandrock overlying the Georgia group unconformably, as already stated, the Granular Quartz and the Potsdam must have the same stratigraphic position.* While this has not been observed in New York and Vermont (or when so seen the overlying strata were considered to belong to the Red sandrock) it has been observed to be the relation subsisting between an identical quartzyte in the area of the original Huronian, in northern

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* Bull. No. 30, U. S. Geol. Sur. p. 18.

† Geology of Vermont, Vol. I, pp. 260, 817. The Taconic of Georgia and the report on the Geology of Vermont, *Mem. Boston Soc. Nat. Hist.*, *Vol. IV.*

‡ American Geologist, March, 1888. A great primordial quartzyte.

Michigan, and in northeastern Minnesota, and a series of slates underlying. In other words; The Thessalon quartzyte of the Huronian overlies (probably) unconformably the Plummer argillytes. The Pewabic quartzyte and the Wanswaugoning quartzyte overlie the Animike in northern Minnesota, but the exact contact has not yet been observed; while in the Marquette region the "quartzyte group" of Rominger overlies unconformably his "iron group."*

If we carry the comparison further:—

(d) *The stratigraphic relations of the Granular Quartz and Potsdam to the "granite" are the same as those of a great primordial quartzyte of the Northwest to the "granite."* This western quartzyte has been designated, not only Potsdam, but Sioux quartzyte, Baraboo quartzyte, New Ulm quartzyte, Barron county quartzyte, Wanswaugoning quartzyte, as well as Pewabic quartzyte, and in numerous instances it has been observed to lie unconformably on the granite supposed to be of Laurentian age.

This comparison could be extended to include the Black Hills of Dakota and the primordial section of Nevada, and it would appear that the relations here pointed out for this quartzyte are of wide application and mark it as a formation of continental extent.

(e) By Mather, Rogers, and others who have opposed the Taconic system the Granular Quartz was referred to the Potsdam sandstone.

These considerations seem to justify the conclusion that, contrary to the opinion of Dr. Emmons, the Granular Quartz should be placed at the top instead of at the bottom of the Taconic system, and that the Taconic black slate underlies it unconformably. This does not disturb his general idea that the Taconic is a sub-Potsdam formation, even using the term Potsdam in its original sense as here defined. It is, furthermore, in accordance with the views of the Swedish geologists to find the quartzyte (Paradoxides) horizon, lying above the Olenellus beds, and indicates that the Braintree (Mass.) quartzytes overlie the Braintree slates.

[NOTE.—The only intimation that the writer has been able to find that the Granular Quartz and the Red sandrock had ever been regarded the same formation by the early geologists is a statement in the "Geology of Vermont," Vol. I, 1861 (issued in 1862, Walcott), p. 346. It is by Dr. Edward Hitchcock, and in the following words: "A narrow strip of impure limestone partially separates the quartz rock from the Red sandrock in Monkton. The limestone gradually thins out, and is finally lost, so that the quartz rock and the sandrock unite with each other; and probably the line of junction is only a line separating different degrees of metamorphic action upon the same formation;" but by different geologists both the Potsdam and the Granular Quartz have, on what seemed good evidence, at different times been regarded as the equivalent of the Red sandrock. Some confusion has arisen, as it seems, in the use of the word Potsdam, by the geologists who have examined the Champlain valley in the same manner as in the Mississippi valley.* Some have applied the term to the great quartzyte (the "Granular Quartz" in its different positions) and some to the later, looser sandrock, and Calciferous sandrock, that lie unconformably on the quartzyte, and some to both varieties. The former is the horizon of the Paradoxides fauna, from New England to Minnesota, and the latter is the horizon of the Dicellocephalus fauna. It will require a re-examination of the "sandstone of Potsdam," at the typical locality, to determine the question — which is the true Potsdam sandstone ?]

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*Sixteenth report of the Minnesota survey, pp. 45, 46.

The age of the Potsdam.

Equivalent names. Under this heading are included here several local designations which have been applied by geologists to a formation that extends widely over the United States and Canada, the uniform characters of which, as well as its fossils and stratigraphy, indicate that they all belong to one great quartzyte horizon. Some of these various names are: Granular Quartz, Red sandrock, Thessalon quartzyte (of the original Huronian), Teal lake quartzyte, No. 3, or quartzyte group (of Dr. Rominger), Baraboo quartzyte, Wanswaugoning quartzyte, Pewabic quartzyte, Sioux quartzyte. Further east, it may be represented by the quartzyte at Braintree, Mass., and the Paradoxides beds of Newfoundland. Further west it seems to exist in the Mt. Stephen section, and contains the fauna of the Bow River group, and of the "Prospect Mountain" quartzyte. It is unquestionably found in the Black Hills, but fortunately it has not there received a special name, but is embraced under the term Potsdam. This is essentially the horizon of the Paradoxides strata of the primordial.

Unconformable on the Taconic. It has been stated that this quartzyte is unconformable on the Taconic. This is sufficiently established in Vermont, in Michigan, Wisconsin and in the

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* Emmons noticed the difference of lithology, but not the unconformity of stratification. *Geol. of N. Y.*, Vol. II, 1842, p. 269.

Dr. Edward Hitchcock seems to have figured this unconformity in Vol. I, p. 265, of the *Geology of Vermont*, but he considered the "quartz rock" here to belong to the Laurentian. At Chazy Mr. Jules Marcou states that he observed an unconformity between the Potsdam and the Chazy strata, the divergence of dip being 15 degrees.—*The Taconic system and its position in stratigraphic geology*. Proc. Am. Acad. Arts & Sci., Vol. XII, p. 190.

Black Hills of South Dakota. It is presumably so in the area of the original Huronian.[*] Such a widespread non-conformity indicates that the Taconic was closed by a widespread epoch of disturbance. Since the Potsdam is carried over the edges of the Taconic, and in many places is brought into contact with the "granite," which may be supposed to be older than either, it is evident that this disturbance was followed by a still further inroad of the oceanic waters on the land area of the continent. This submergence has effectually hid the Taconic formation from sight over very extensive areas, and led the geologists who saw the Potsdam lying on the Primary, in New York, to question the possibility of a formation several thousand feet in thickness belonging between them. It also produced a conglomeritic composition in the bottom of the Potsdam at nearly all places where the bottom beds have been seen.

Further evidence of disturbance during the Potsdam. The gradual or paroxysmal sinking of portions of the continent below the ocean during the Potsdam age was accompanied by other evidences of disturbance that have remained undeniable witnesses to this day. There were both basic and acid eruptions of great volumes of molten rock, which in some cases were interbedded in the Potsdam, and in others are found overlying it. These molten rocks are found generally to lie on the Taconic and the Potsdam both, but their date of outflow is fixed later than the beginning of the Potsdam by their stratigraphic relation to the Potsdam. Beds of gabbro are evenly spread with quartzyte strata above and below them, in the Pewabic quartzyte in northeastern Minnesota. In general the gabbro lies on the Animike (Taconic) in Minnesota, but a favorable observation made at Chub (Akeley) lake[†] demonstrates that this quartzyte was partially deposited over the Animike before the great gabbro flood occurred. The usual immediate overlie of the gabbro on the beds of the Taconic, is due to the fact that those beds were nearer adjacent at the points of issue of the molten rock. It also lies on the Keewatin as well as on the Laurentian; while the Potsdam is overwhelmed and nearly lost by the great mass of lava that issued from the interior of the earth during the time of its deposition. While the gabbro outflow seems to have been the most voluminous and remarkable in Minnesota, and to have been the earliest of the basic Potsdam eruptions, in the area of the original Huronian the Thessalon quartzyte is generally cut by and buried under an eruptive of a slightly different kind, more resembling some of the "traps" of the later epoch. There is reason to suppose this may be due to one of two causes. 1st. That at the time of the gabbro flood in other regions the area of the original Huronian was exempt (or nearly so)* from eruptive disturbance, and that the later basic outflows took place there after the region was elevated above the ocean; or 2nd. That while typical gabbro rock was being extravasated in Minnesota, and in some other portions of the country, a slightly different basic eruption was taking place in the area of the original Huronian. From the fact that some gabbro rock is found in the region of the original Huronian, it appears that the former of these hypotheses is more probably correct, and that there as well as in northeastern Minnesota, the basic diabase and finer trap-rock characteristic of the most of the Kewenawan, were of somewhat later date than the gabbro. That these darker, diabase traps issued at some date after the gabbro flood, is evinced not only by the dikes of the former that cut the latter, but also by the remarkable puddingstones of gabbro that are formed by the inclosure of isolated, transported masses within the diabasic sheets,† seen in the vicinity of Beaver Bay.

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[*] In the St. Louis valley, near Thomson, the basal conglomerate of the Potsdam is unconformable on the Thomson (Taconic) slates. Tenth Minnesota report, p. 33.

[†] Sixteenth report, pp. 85 and 87.

This basic eruption characterizes this geological horizon throughout its extent in Minnesota, but toward the east it seems not to have been so characteristic. It prevailed in some parts of Canada‡, and disturbances in the so-called "Quebec group" appear to involve this horizon of rocks. The Adirondack region has not been examined except about its margin. It is believed that this quartzyte exists in many places involved with the gabbro rocks of those hills. Its outcrops about the flanks of these hills have been described at places where most accessible and named Potsdam sandstone. These descriptions are applicable to this quartzyte in Minnesota—even to the vitrified surfaces that are so common in the west,§ and which are not known to have been seen on any other formation though exposed in similar circumstances.

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*One small knob of gabbro was seen near Otter Tail village. Compare 16th report, p. 29.

† Norwood, in Owen's report on Iowa, Wisconsin and Minnesota, p. 366; also Ninth Rep. Minn. Sur., pp. 80-81; Tenth Rep. Minn. Sur., pp. 112-113.

‡ Geology of Canada, 1863, p. 483, 865, 875, 879; Geology of New York, 1843, Mather. Part I, p. 444.

§ Geology of Minnesota, Vol. II, 1888, page 516, foot note. Geology of New York; Second district, Emmons; p. 269.

Post-gabbro eruptions of the Potsdam age. It has been difficult to affirm, until recently, the age of the gabbro outflow. It has generally been considered to have followed the Animike (Taconic) but that it was later than the commencement of the Potsdam was not known to the writer till he made the observations referred to above.* What were the relations of the later basic eruptions of the "Kewenawan" to the gabbro has been described by Prof. Irving and by numerous other observers. There is no reason to affirm a long lapse of time between them, sufficient to allow the formation of an oceanic terrane requiring special designation. The later eruptive rock embraced and probably transported loosened masses from the gabbro, as evinced in the "feldspar masses" described by Norwood near Beaver Bay on the north shore of lake Superior, and the puddingstones observed by the writer. But this, rather than indicating a long intervening time, seems to imply a quick succession in the eruptions, or else a continued elevation above the sea so as to prevent the accumulation of intervening sediments. That there was no exemption from sedimentation after the gabbro is shown by, (1) the absence of any sign of ancient land surface, (2) by the continued and frequent interbedding of eruptive and sedimentary rocks through the entire Kewenawan (Geol. of Wis. Vol. III, p. 403), and (3) by the gradual transition of the basal conglomerate of the Potsdam, in favorable places, from a siliceous, or pebbly-quartzose, character, through a siliceous sandrock to a feldspathic sandrock, and to a pebbly volcanic tuff. Such transitions are frequent on the north shore of lake Superior. One of the most important observations was recorded in 1879,† when the basal quartzose conglomerate of the Potsdam was found dipping in consonance with the shales and tufaceous conglomerates of the overlying Kewenawan, in the St. Louis valley, unconformable over the Thomson slates, and embracing lenticular spots of shaly rock and red (Kewenawan) conglomerate as constituent and conformable parts of itself. This shows a conformable, though somewhat intermittent, course of sedimentation from the basal conglomerate into the typical detritus of the overlying beds of the Kewenawan; the interruptions and the changes in the nature of the sedimentation being attributable to

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*Sixteenth annual report, pp. 85 and 88.

†Tenth report, pp. 11, 32, 33.

'e disturbances that took place in the adjoining
will be seen at once that this links the Kewenawan
ro, and both to the Potsdam.

tions during the Potsdam. The dynamic forces that
bring molten basic rock to the surface of the earth
ern Minnesota also softened the acidic strata of the
which in some places seems to have culminated in
protrusions and lateral displacements of large masses.
eruptions, ranging from felsitic to granitic, are of
unts in Minnesota and Wisconsin. Sometimes they
act with the Taconic strata as at Duluth (10th
), sometimes with the Potsdam,* and sometimes with
uptions of the Potsdam.† They are seen in contact
conic slates of the original Huronian (16th Report),
em to be the direct result of change from some sedi-
iceous strata.

this feature of the Potsdam is persistent through
ada, and in New England, is uncertain, owing to
ice of definite "Laurentian" theories as to the age
he granitic rock that geologists have studied in that
country. There is, however, every reason to affirm
d and profound volcanic disturbance, extending from
ills, at least, to Vermont and eastern Canada, that
ie Potsdam era and closed with that era, and that
results in the forms of acid as well as basic eruptive
ntioned above for the Northwest, must characterize
ion in New England, there is good reason to expect.
e descriptions of such phenomena have been pub-
. Hitchcock mentions some Potsdam schists that con-
of granite whose feldspar is labradorite" (Geol. of
'ol. I, p. 264). There are many instances published
lates of the Taconic including the granular quartz
ed as to run beneath masses of granitic rock, but
sibility has been negatived promptly by resort to
ypothesis of a fault, to bring up the "Laurentian."
s describes such instances.‡ Similar facts have been
by Prof. C. H. Hitchcock§ in New Hampshire,

Visconsin, Vol. II, pp. 251, 506, 522.

esota report, p. 110.

New York: Second district, 1842, pp. 141, 145, 159. Agriculture of New York
, 94.

eologist, April, 1889, p. 254. Geology of New Hampshire.

although there is no certainty that the slates described
are of the age of the Taconic. Prof. Hitchcock makes i
apparent that the granites of New England cannot
placed in the Laurentian any more than they can in Mir

The Potsdam age closed, therefore, with the cessation
disturbances and volcanic eruptions which introduced i
beds that were formed were left in upturned and fractu
tudes for the attacks of the succeeding St. Croix age.
strata embraced not only the basal quartzyte of the P
but the gabbro, and all the succeeding eruptions that ar
in the Keweenawan. Here would necessarily appear a
and extended plane of unconformity, and this fact, whe
ciently recognized, will be found to distinguish the r
many places — whether Potsdam or St. Croix — and be a c
by which to judge of their stratigraphic place in the ge
column. In other words, the Potsdam is unconformable
older gneiss and slates and schists, and is cut and cove
eruptions of the same age as itself. It would not norr
found unconformable on rocks of its own age over wid
although contemporaneous disturbance might certainly
local non-conformity. The later formations may show r
formity over wide areas of the rocks of the Potsdam, a
we find to be the fact.

The age of the St. Croix sandstone.

That it may be made plain to the reader just what st
considered by the writer the Potsdam sandstone, this
may be carried one step further. This is the more n
inasmuch as some of the steps in the history which a
known in the Northwest, have not yet been recognized,
not been admitted as facts, by most of those who have e
the geology of the Champlain valley. It appears that
widespread succession of physical changes affected th
paleozoic and crystalline terranes in America with a un
of effect that is surprising, and which leads to very
questioning of the doctrine that formations can not be re
by their lithology from place to place because of the lia
physical change. There is, in fact, a remarkable persis
lithologic characters, and of stratigraphic relationship,
Minnesota and New England. The satisfactory establish
some points in the geology of the Northwest throws mu
on moot points in the geology of the east. While most o

incidences and identities have to be reserved to a later dis- ssion, one of the most interesting concerns immediately the rmation which is under consideration — the *St. Croix sandstone* f the Mississippi valley, and its relation to the Potsdam.

The separateness of the St. Croix from the Potsdam. It has already een stated that some confusion has been introduced by the use f the term Potsdam by different writers in different senses. This began with the early descriptions of the geology of eastern New York, Vermont and Canada. This confusion was one of the most btrusive problems that confronted the writer in 1872 in the preparation of his first annual report. In order that a more definite understanding might attach to whatever he should be alled on to publish respecting this horizon he chose to designate he lower formation Potsdam and the upper one St. Croix, and his distinction has been observed in the later publications. If ot correct it has at least served to give definiteness to all is descriptions.

This problem was given pointedness a short time prior to the eginning of the Minnesota survey by the writings of Prof. R. D. Irving, who had shown that in Wisconsin the upper formation was unconformable on the lower.* Irving's papers on the Wisconsin quartzytes proved the existence of two formations in places where hitherto, by some, there had been supposed to be ut one, and, assuming the upper, or horizontal, beds to be the Potsdam, based on the conjectures of Prof. James Hall published n the Sixteenth (N. Y.) Regents' report, he announced the upper one to be the equivalent of the New York formation and he lower one he relegated to the "Huronian," that convenient imbo to which it has been customary to consign uncertain stragglers from the upper "Silurian" and from the nether "Laurenian." It was not presumed at that time that the geology of the Northwest would be found to tally closely with that of New York, and as there was no mention of such a great "Huronian" quartzyte there, nor in New England, the presumption was that the "Huronian" was a formation that affected Canada and the Northwest, and that, therefore, this great northwestern quartzyte would not be found further east than the northern shore of lake Huron. Only the "Potsdam" was described in eastern New York.

Upon pushing the distinction further east, however, and upon making a wide study of the older terranes, which, when better understood, are found to exhibit a surprising concord of essential features with those of more eastern as well as western regions, it is found that there is every reason to believe, not only that there exists the same great underlying quartzyte in New England and eastern New York, but that there are unmistakable evidences of the same non-conformity between it and the overlying horizontal, or nearly horizontal, beds. Moreover, it is equally plain, on making an examination of descriptions that have been published by the eastern geologists, that both the formations have been with great positiveness called Potsdam sandstone. It is very evident that no little misunderstanding has resulted from a failure to observe and acknowledge this important line of non-conformity. But wherever it has confronted the geologist in Vermont or eastern New York, it has been glided over indifferently or has been accounted for by some outre hypothesis, such as "overturn" or "fault," or temporary "non-deposition," or "metamorphism from contact with the Primary."

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* Am. Jour. Sci., Feb., 1872; April, 1872.

In order to support this statement some references will be made to the published descriptions of the "Potsdam" in New York. No reference will be made to the Granular Quartz nor the Red sandstone, both of which the writer believes, as the reader will have observed, are identically and only, the Potsdam formation; but to some statements concerning the "Potsdam sandstone" as understood by the geologists who made them.

Emmons. In his report on the geology of the Second District, 1842, Dr. Emmons uses these words in describing the Potsdam in Essex county—"In consequence of this rock presenting two quite distinct varieties, and those varieties being well developed, the one at Potsdam, St. Lawrence county, and the other at Keeseville, I have sometimes given it a compound name—the *Potsdam and Keeseville sandstone;* for the reason that at the former place a beautiful granular variety, and at the latter a harder and more crystalline mass predominates, which resembles the granular quartz of the Taconic system." Near Keeseville the rock that outcrops he describes as exhibiting some interesting changes upon the surface of the layers, presenting "a smooth and semi-vitreous surface—a kind of glazing;" by which he seems to have meant the same polished or glazed surface that appears frequently on the Potsdam in Minnesota. It is plain, therefore, that Emmons noted the contrasting lithology, but, so far as the ıas observed, he did not recognize any unconformity in ɔtsdam," or between it and the Calciferous.

'tchcock. There is not much doubt that Dr. Hitchcock ĸactly an unconformity between the two formations at Iaven (Geol. Vermont, Vol. I, p. 265), but he regarded er one as a part of the "Laurentian," and the upper as sdam. He states that "the only way of distinguishing the ;ian character of the [lower] deposit is by the higher dip trata, upon which the Potsdam sandstone rests uncon- y. A section passing across the south end of West in fig. 168, represents the unconformable relations of the ;ian rocks and the Potsdam sandstone to each other. t not for this discordance in the stratification we should the lower rock as Silurian because it does not differ ically from the sandstone above. But in following the ıorthwardly the quartz rock becomes more gneissoid. ' the specimens in the cabinet are very distinct gneiss, them with the labradorite, the characteristic species of spar of the Laurentian series."

ıe reader compare the description of the "quartz rocks" ,aurentian with the following description of the "Pots- *t the same place.*

third variety very closely resembles the Laurentian It seems to pass into it by insensible gradations. The ns obtained are from the southwest part of West Haven. constituents of this rock are very small, and occasionally spar or the mica may be wanting * * * Associated ese crystalline schists are veins of granite, whose feld- labradorite. This mineral is mostly confined to rocks ıe Silurian system; and in West Haven it extends only a into the base of the Silurian, and that in small veins ree to ten inches wide.

unconformability of the dip of this rock to the Lauren- ıeath [sic] may be seen at the extreme southern point of 'aven. Upon the lake, opposite the termination of the l the dip of the older rock is 36° East, and only a few ıt the dip of the sandstone is only 9° East. As the south West Haven terminates in a cliff this section can be ıtinctly from quite a distance. The rock with the greater s distinctly quartz rock as the other, and there is also a dge of quartz rock upon the west side of lake Champlain .e same inclination. Hence the sudden change in the dip is to be regarded as a safer distinction between the Silurian and Laurentian series than a difference in lithological character."

Setting aside Dr. Hitchcock's identification, either of the following interpretations of the facts, in the light of what has since been learned of the geology of the Taconic and the granular quartz, would be possible. (1) The lower rock is the Potsdam (granular quartz) and the upper is the St. Croix; or (2) The supposed unconformity is only an illusive appearance in the same formation, perhaps false bedding, or oblique stratification, or a sheeted disintegration which sometimes is superinduced by weathering even in the firmest crystalline rocks. In the light of further considerations the latter explanation seems most probable.

(a) Prof. C. B. Adams had stated in his first annual report that the Potsdam sandstone only reached within half a mile of the state line near Whitehall, and did not enumerate it at all in his table of Vermont formations.* If this were true it would be necessary to consider this West Haven quartzyte as the Red sandrock or the granular quartz. Either of these explanations, to so strong an opponent of the Taconic as Hitchcock was at that time,† would be avoided if possible. For, to class it as a part of the Red sandrock spur that shoots southward from the town of Monkton, the last remnant of which his map represents on the south line of Orwell, bearing in a direction toward West Haven, only seventeen miles distant, would be to bring the "Medina sandstone" below the Calciferous which exists in the immediate vicinity and into contact with the Laurentian; which would necessitate the abandonment of the "metamorphic" idea that the Red sandrock and all the Taconic rocks were changed conditions of the Lower and Upper Silurian of the Champlain system of New York. Also, to admit that it is an outcrop of the Granular Quartz of Dr. Emmons, would in like manner bring the Granular Quartz beneath the Calciferous and even unconformably beneath another sandstone that might be the Potsdam; this would substantially confirm everything that Emmons claimed for his Taconic. These alternatives were clumsily obviated by introducing the Laurentian. That this "Laurentian" is the gabbro of the Potsdam age is probable from the nature of the feldspar which it is said to contain.

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*First annual report, Geology of Vermont, 1845, p. 61.

†It is evident that a change of opinion was accomplished in Dr. Hitchcock's mind during the preparations of this report. This is intimated in Vol. I, p. 435.

, *Mather*. So far as discoverable all the descriptions of . by Prof. Mather* apply to the lower or quartzyte divi- [e notes repeatedly his belief that the Granular Quartz ımorphic condition of the Potsdam.

nuxem distinctly mentions the same varieties of rock otsdam as Dr. Emmons, and employs the double desig- 'Potsdam and Keeseville sandstone," but he mentions ıformity. He intimates, however, that the Potsdam, in textured variety, is with difficulty distinguished from iferous sandrock. The latter he describes at numerous ı immediate contact on the primary.

n. Logan. In the *Geology of Canada*, 1863, this formation fied into "Potsdam group," and includes a thickness, on ̣awrence river, of 540 feet. This group embraces not true Potsdam but several beds of conglomerate, white ıe suitable for glassmaking, fucoidal beds, limestones and ır breccia like that described by Emmons at Chazy and eparate the Potsdam from the Calciferous. The fauna ppertains to the upper layers is that characteristic of iferous. It is evident that the true Potsdam is here led with the overlying St. Croix-Calciferous, and that iferous is restricted in the words of Logan, essentially, anular magnesian limestone or dolomite, which from its eathered surface and slight effervescence with acids may ggested the name of Calciferous sandrock." In the eports the Potsdam had not been recognized about lake but the lower great quartzyte had been included, along the strata equivalent to the Taconic under the term ın. His opinion of some quartzyte beds on Murray bay t first Logan regarded as Potsdam, and which he so d (*Geol. of Can.*, 1863, *p*. 96), he modified by adding a foot- ting that it had been ascertained by Dr. Dawson that ıuartzytes really belong to the Laurentian series."

Hall. The Potsdam sandstone does not occur in the District, on which Mr. Hall reported, but he examined ı north side of lake Ontario, and subsequently on lake r and in the Mississippi valley. His general description ıport on the Fourth District is such as would apply to ır quartzitic portion.

lake Superior report of Foster & Whitney (1851) the ich was inaugurated by Logan in the creation of the

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y of New York, First District, 1843.

"Potsdam group," embracing the quartzyte and the overlying sandstone in one designation, was completed by the entire severance of the lower formation from the name, and its application only to the upper or nearly incoherent sandstones. At the same time the quartzyte, along with all the strata of the Taconic associated with it, were included in the "Azoic," embracing both the Laurentian and Huronian. This upward movement of the names of the New York formations, is shown by the following words (p. 114): "The Potsdam sandstone of New York is a quartzose rock whose particles are firmly aggregated, while the the same rock, on the northern slope of lake Michigan, is so slightly coherent, that it may be crushed in the hand. The Calciferous sandstone of New York, when traced west, passes into a magnesian limestone." This supposed change in the nature of the formations toward the west is largely imaginary; the change seems to consist rather in the transference of the original names to strata higher in the scale, and the creation of new names for the abandoned strata. All the authors of this report, including Prof. James Hall, apply the name Potsdam only to the friable sandstones which are unconformable with the Copper-bearing traps and basalts which, as already shown, are of the age of the lower quartzyte.

As to the paleontology of the Potsdam in New York, which is quite meagre if the more recent additions from the Calciferous be disregarded, an interesting problem centres on the fossils Lingula (Obolella) prima and (Lingulepis) antiqua. By Prof. Hall these are assigned to the Potsdam. In respect to L. prima it is reported at Keeseville on the authority of Dr. Emmons, and it is reported from the Mississippi valley on the St. Croix river. To the writer the St. Croix beds have been known for some years as belonging about to the horizon of the Calciferous, and they have been so parallelized by Irving.* The Calciferous, here including the magnesian limestone known as Lower Magnesian, is unconformable on the trap rock, and, in common with the sandstone underlying it, becomes conglomeritic by reason of such unconformable contact. The beds here exposed are not so low as the lower layers at Stillwater where the first specimen of Dikellocephalus was discovered by Dr. Owen. It would seem, therefore, if we can depend on the indications of paleontological evidence, that the Potsdam at Keeseville, containing Lingula prima would be considered substantially the parallel of the Calcif-

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*U. S. Geol. Sur. Monogr. V. Copper-bearing rock, of lake Superior, p. 446.

ds at Taylor's Falls in the St. Croix valley. What are
? On re-examining Dr. Emmons' description of the sand-
the Au Sable river in his report on Essex county, he
t this general range of sandstone, containing the Lingula.
ccording to Hall, *reposes against the hypersthene rock*, (i. e.,
bro) and contains Lingula antiqua; and Prof. Hall cor-
is indentification of Emmons by saying the species
by him from this place is not L. antiqua but L. acumin-
Conrad, which is a Calciferous species, and does not
to his knowledge, in the Potsdam.* Therefore all the
e from paleontology and from stratigraphy, so far as it
gathered from the report of Emmons and the first vol-
the Paleontology of New York, indicates that the beds
St. Croix are the equivalent of those described at Keese-
d that both belong to the Calciferous; at least that they
later than the eruptive epoch of the Potsdam as here

rief examination of some early descriptions of the Pots-
New York, which might be extended to include several
ames, is sufficient to prove the truth of the foregoing
nt that the distinction which has been made in the North-
uld with propriety also be made in the East, and that a
f non-conformity between the Potsdam and the Cal-
extends through eastern New York and Vermont, and
re, as in Minnesota, the upper (St. Croix) sandstone has
affiliations with the strata that succeeded the break than
ose that preceded it.

is review it is assumed that the "sandstone at Potsdam"
d this non-conformity. It is evident that some re-exami-
should be made of the region before this can be considered
hed. Dr. Emmons, in his section passing from Canton
hville (Plate ix. *Geol. of New York*) shows that *gneiss* ex-
Potsdam below the sandrock, and this rock he always
efinitely distinct from *hypersthene rock*, which he argues
vated at a later date than the Green mountains. The
lism of position between the Potsdam sandstone at
m, and the Granular Quartz, in this respect, both lying
e gneiss, not only indicates a possible parallelism of age,
t they are possibly older than the Keeseville sandstone
rests against the hypersthene rock.

further assumed, in this review, at least in making the

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put in the "Potsdam group" by Logan, Geol. of Can., 1863, p. 102.

extension of the western parallels to the east, that the gabbro of the Northwest is the chronologic analogue of the hypersthene rock of the Adirondacks. The lithology is identical, except that various "limestones" are mingled with the hypersthene rock which have not, so far as known, any parallels in the gabbro of the Northwest. This assumed parallelism may also be set down as not sufficiently established.

It is also assumed that the Pewabic quartzyte of northeastern Minnesota, with which gabbro is interbedded and which lies below the great gabbro overflow, is the equivalent of the Wauswaugoning quartzyte and of the Pipestone quartzyte of the southwestern part of the state carrying a primordial fauna, which last is very certainly the equivalent of the Thessalon quartzyte of the original Huronian. Still the Pewabic quartzyte may not hold this relation to the Wauswaugoning beds; the connection has not been traced; yet they seem to be similarly situated with respect to the gabbro sheet, and are not widely separated from each other.

The writer has attempted to indicate such general equivalency as has appeared to him probable, and which embraces a greater fund of concordant fact and testimony than any other scheme of chronologic succession. He may be wrong in some parts of this history, and especially in the extension of the story as made out in Minnesota to eastern states, and holds it, in large measure, as tentative at this stage of the investigation. When facts can be found out sufficient to correct it in any way, he will be glad to welcome them, for he freely admits that there are questionable steps and missing links in the history, which have to be bridged by hypothesis and nothing else. That is, however, the nature of all investigation, and especially of all attempts to formulate any general truth.

PROBLEMS THAT NEED FURTHER INVESTIGATION.

As already stated, as this investigation has proceeded, no sooner did we surmount the difficulties which immediately beset the first attempts than new difficulties appeared. The solution of one problem seems to serve for vantage ground to behold others in the greater distance. It will be desirable to mention some of the questions that appear at present to require further study, and further field-work. This will distinguish more exactly the status of our present knowledge, or body of truth on which we rely, from the realm of hypothesis or of unfinished work and research, to which it will be necessary to devote the efforts of the survey at some future date.

Eruptive and sedimentary Laurentian. Beginning with the Laurentian, as defined above, one of the unfinished courses of study relates to the distinctions, both geographic and structural and petrographic, between the eruptive masses of syenite, or granite, and those that are supposed to have resulted from change *in situ* of the oldest sediments. This will involve the further question whether the "gneissic structure" is necessary, or even possible, in a truly eruptive rock. But first of all it will necessitate a correct definition of the term "gneissic structure."

There are three distinct ideas that have been confused under the term gneiss, or gneissic structure. No reference is made here to the use of the term gneiss as a rock species, but to the structure which is supposed to distinguish it, the proportionate amounts of the usual mineral ingredients being variable, and sometimes constituting a dark-colored, perhaps basic, rock, and at other times an acidic one. Referring only to *structure*, therefore, a rock has been said to be gneissic when *foliated;* but it is plain that there may be different kinds of foliation, (a) that lamination which consists of an undulating layered structure, the mica element not being unevenly distributed, but all the scales being parallel with the sheeting, and all the grain of the rock having a uniform structural rift which facilitates quarrying. If there be a finer lining or sheeting of the mica element the lines or sheets are not continuous far, and may be seen to fade out within a distance of a foot or two. That is to say this foliation does not indicate a profound separation of the minerals of the rock into layers or long continuous sheets. (b) A second sort of foliation is that which arises from a distinct separation of the minerals of the rock, or different proportions of the constituent minerals, into sheets or strata that continue over long distances. Such separation is indicated on the weathered surfaces by color-bands, and by petrographic differences of grain and composition. In short this foliation is plainly a modified sedimentary structure. The sheets, or layers, or strata, into which the rock is separated, are traceable over large surfaces. The crystalline condition of the grain here may be as perfect as in the last, and this constitutes the "crystalline schists;" but in many places there is seen an imperfect, or interrupted, crystallization, the various grains blending round their borders into each other, or being lost in an indefinite matrix, or developing porphyroidally. (c) Still another structure has been styled gneissic. A massive homogeneous rock, which may have neither of the foregoing kinds of foliation, but which exhibits the micaceous or hornblendic element evenly distributed in isolated individual grains throughout the whole, yet is seen to have a uniform elongation of the separate crystals, of all kinds, in the same direction. This furnishes also a kind of rift or grain which pervades the mass, rendering it easier to break in the direction parallel with the greater diameters of the crystals than in any other, but it is essentially a massive non-foliated rock. A massive structureless granite, or syenite, is rare to see. Hence by far the greater part of the Laurentian, whether eruptive or sedimentary, is properly styled gneiss. It is obvious, however, that these three structures should not all be described by a single term.

When these structures are once sufficiently differentiated in the mind of the observer, and are carefully applied in descriptions, there will still remain to ascertain what relations they separately sustain to the supposed two sorts of Laurentian rocks, i. e. whether one or the other may be found to characterize the actually eruptive acid Laurentian, or the metamorphosed sedimentary Laurentian.

Planes of hydro-thermal fusion, and their relation to the origin of the crystalline schists. A second problem connected with the Laurentian, and which appears prominently in the horizon of future research, relates to the origin of the crystalline schists.

It has been stated above that there is every evidence to suppose that the eruptive epoch which introduced the Vermilion age (i. e. the crystalline schists) continued into the Kewatin (i. e. the sericitic schists and graywackes) by an unbroken and uniform succession of events and oceanic deposits. This binds the Vermilion and the Kewatin, historically, closely together. It has been said also that the mineral characters of the Vermilion fade out very slowly into those of the Kewatin, but that when fully established the change is so great that the formations have great mineralogical contrasts. In other places the crystalline schists have a very feeble development at the horizon where they would be expected to appear, and the Kewatin graywacke-like sediments pass into the Laurentian sediments through a gradual change from graywacke to gneiss—a gneiss having the second kind of foliation described above.

The crystalline schists seem to be, nearly always, as completely ystalline as the gneiss. If the origin of the basic sediments of e crystalline schists be akin to that of the sericitic sediments the Kewatin, viz. from volcanic ejectamenta, the query quickly ises—why are they not similar in the resulting rocks? Why e the crystalline schists so uniformly composed of the same inerals as make up gneiss, though differing from gneiss in the lative amounts of those minerals and in the evident sedimen- ry structure, while the Kewatin, sericitic schists are only sub- ystalline and are often earthy? Is it not plausible to suppose at the crystalline schists are but a phase of the earthy Kewatin hists, due to the encroachment of hydro-thermal fusion-planes on them? At the present time these beds all stand nearly rtical. If this fusion affected them after this verticality was tained, it may be supposed that the approach of the fusion- ane toward the surface of the earth would be nearer in some aces than in others. When the fusion was accompanied by cture more or less of the fused rock-matter would be thrust rough the fissures and would appear as eruptive rock. Since ere are certainly places where in the Kewatin sediments such sion, and even such eruption, seems to have resulted from the watin itself; and since in the immediate vicinity the sedi- nts adjoining take on over a greater or less width, the charac- s of the crystalline schists, and at other places the crystalline iists do not appear where the Kewatin sediments exhibit that culiar semi-crystalline condition which has been mentioned as orphyrel," it has appeared to the writer that very likely the ystalline schists have no constant stratigraphic place, any ore than the Laurentian gneiss, and that the "crystalline" phase s been superinduced *in situ* on basic (or acid) sediments in strata different ages, according as, after being deposited, and even ter being tilted to verticality, the level of hydro-thermal fusion as able to reach them or not. Therefore, without any undulat- g of the actual strata in anticlinal and synclinal folds (a sup- sition which seems to be precluded in some places by the tensive present vertical position of all the strata), there ill might result, superficially, successive belts of rocks of fferent kinds. The belts would express the effects of hydro- ermal fusion, perhaps on the same sort of sediments, in differ- t degrees of intensity. Wherever erosion and denudation ay have been sufficient to bring the present surface down to e level where the fusion-plane operated in its full intensity, there we should find the present surface rock to be gneiss if the sediments were acidic, crystalline schist if the sediments were partially basic and stratiform, or eruptive rock if there were fissures through which such could and did escape. Where the surface erosion has not been sufficient to expose the upward (or the downward) undulations in the plane of perfect fusion, we find the earthy, or volcanic, or siliceous, sediments more nearly in their original condition.

Date of upheaval of the crystalline schists. Intimately connected with the question of the origin of the crystalline schists is the question of their date relative to the epoch of their upheaval, and the further, or prior, question as to the cause of the very general and extensive verticality of all the sedimentary strata that precede the Taconic (Huronian).

Nature and origin of jaspilyte. Attention has been called to some points in the investigation of this question which need further examination.

What is the "muscovado rock?" and, particularly, does it represent a sedimentary formation younger than the Kawishiwin and older than the Taconic.

COMPARISON OF THESE RESULTS WITH THOSE REACHED ELSEWHERE.

Following is a tabulated statement of the general stratigraphy supposed to exist in Minnesota, according to the foregoing sketch.

Calciferous. Magnesian limestones and sandstones.................................... } Dikelocephalus horizon.
St. Croix. Sandstones and shales........... }

Overlap unconformity. ———————

Potsdam. Quartzyte, gabbro, red granite and Kewenawan............ Paradoxides horizon.

Overlap unconformity. ———————

Taconic. Black and gray slates and quartzytes, iron ore, (Huronian, Animike)...................... ....Olenellus horizon.

Overlap unconformity. ———————

Kewatin (including the Kawishiwin or greenstone belt, with its jaspilyte), Sericitic schists and graywackes................. } Archean.
Vermilion (Coutchiching), crystalline schists }

Eruptive unconformity. ———————

Laurentian. Gneiss...... .... }

For greater details respecting these parts the reader referred to Vol. III, Wisconsin geological report, pp. 106-166.

The Kewenawan system Prof. Irving here describes as co sisting of a "lower division, embracing chiefly great flows gabbro, diabase, and melaphyr, and an upper division compo chiefly of reddish feldspathic sandstone, subordinate to wh are heavy beds of boulder-conglomerate, indurated gray brown quartzless sandstone and black shale." Among eruptive rocks he includes gabbro, diabase and diabase amyg loid, melaphyr, granite and porphyry, the last being poss clastic. Among its fragmental he notes boulder-conglomer black and gray shales, gray and brown quartzless sandstone red sandstone and shale.

Unconformable over the last he places the light-colored " Superior or Potsdam sandstone," which he considers either "equivalent or downward extension of the Potsdam sands series of the Mississippi valley."

It is evident that in this description there is included notl that answers to the Kewatin and Kawishiwin. It appears a feeble representation of the crystalline schists is noted in nection with the Laurentian, as "dark hornblende gneiss Essentially all of these parts, from No. I to No. XX inclu are the Animike of northeastern Minnesota, the real Huro without the overlying Thessalon quartzyte. According to ob vations already recorded this overlying unconformable qu yte is in northern Minnesota interbedded with gabbro sh and the great gabbro flood lies on the lower portions of it. a natural inference that in an epoch of successive volcanic e tion like that which followed the gabbro outflow, a quart would locally lose its typical character, and would be conve to feldspathic sandstones, conglomerates and shales, and these would be interbedded with the eruptive sheets. seems to have been the case in northern Wisconsin and in n eastern Minnesota within the area affected by this remark series of eruptions. But in central Wisconsin, as well southern Minnesota, and in S. Dakota, the normal condi again prevailed, and a similar quartzyte is found to repeating the sedimentary succession that obtains in the ar the original Huronian.

The peculiar "mica schists" cut by intrusive granite, sented to overlie all the rest of the Huronian, seem not to been identified in Minnesota. There is, in connection wit

:o, in northeastern Minnesota a large amount of red granassing to felsyte such as that seen at the *Great Palisades*, on orth shore of lake Superior. It is possible that in connecrith this granite will yet be found some micaceous schists ering to these in Wisconsin, the result of metamorphism some of the Animike beds.

)f. Charles E. Wright and major T. B. Brooks, who report, } same volume, on some of the crystalline rocks of Wisconresent substantially the same classification. But they disy include the "crystalline schists" in the Laurentian. ts, who made out this order first in the Marquette region, ave the parts similar numerical designations, groups them ee principal parts, viz.:

Upper Huronian, Beds XIV to XX.

a slates, mica schists, granites and gneisses.

Middle Huronian, Beds VIII to XIII.

ırtzytes, clay slates and obscure soft schists.

Lower Huronian, Beds I to VII.

ırtzyte, marble, iron ore, novaculite.

ok's stratigraphic scheme is subject to criticism, and is uous and certainly incomplete, although for a pioneer pt to set the stratigraphy of the region of Marquette into a ance of chronological succession it deserves great praise, supplies the first general classification and gives form to a d mass of variant and unfinished observations and isolated hat had been published before. Since the examinations by Brooks the whole country has been much cleared up, new openings have been made and the geology is much to ascertain with certainty than ever before. Dr. C. ıger, in a later survey, was aided by some of these advanand in some instances he was enabled to correct the stratiic scheme of major Brooks. His report, however, is, as it ses to be, mainly a description of facts, without much to decipher the stratigraphy.

Rominger hesitated about placing the granitic rocks of the ıette district as the parallel of the Laurentian of Canada, gh he regards the rest of the series, with some noteworthy ences, as the Huronian. He rejects the twenty subdivisıade by Brooks, as altogether too numerous and somewhat vague, and some of them he omits from the succession, regarding them as intrusive masses belonging really to lower horizons. The two quartzyte members, of Brooks, he considers but one. With slight exceptions Dr. Rominger's descriptions and classification are in accord with the general stratigraphy and all the geology of the Northwest as now held by the writer. Those exceptions consist, principally, in dividing the strata concerned into two distinct formations, separated by a plane of unconformity which exists everywhere and is observable (and has also been mentioned many times by him), in the iron regions of both Minnesota and Michigan. Brooks paid but very little attention to the rocks embraced by Rominger in his serpentine and dioritic groups. But these constitute, in accordance with the conclusions of this report, the basement floor on which the true iron bearing formation makes an unconformable overlap succession, and are the southern representatives of the sericitic and chloritic schists and graywackes of the Kewatin. Another important difference concerns the great quartzyte of the Marquette region. Dr. Rominger considers it a constituent part of the conformable strata of the Huronian. I think sufficient evidence exists for removing it from the system that embraces the ore beds, and placing it as an unconformable overlying stratum, the equivalent, nevertheless, of the great upper quartzyte member of the original Huronian. Again, the arenaceous slate group, and the iron group, appear to the writer to be, if not identical, very closely associated members of the grand series, and not worthy of separate designation. One may overlie the other, in general, but they probably graduate into each other lithologically and stratigraphically.

In making comparisons, however, the most interesting are found to subsist between this work and that of Mr. A. C. Lawson, of the Canadian survey. In the examination of the geology of the Lake of the Woods Mr. Lawson encountered a series of rocks, which, while included by his predecessors in the Huronian, differed markedly from the descriptions of the original rocks of the Huronian as published by the Canadian survey, and he gave them the name which is used by the Minnesota survey,—the "Keewatin." These he inferred to lieun conformably below the Animike, found further southeast, and they were subsequently traced continuously to the north side of Gunflint lake, and found to become there the very same strata which the Minnesota survey had already described as unconformable below the Animike, but which, however, were not fully wrought out by the Minnesota survey, nor identified as different from the Huronian. In the later prosecution of the work in Minnesota this widespread unconformity has been fully recognized, and the separateness of the strata above it from those below has been established beyond all question.

A still further interesting parallel between the work of the Minnesota survey and that of Mr. Lawson consists in the separation of the crystalline schists. from the Kewatin, under a distinct name, and the recognition of some (at least local) unconformity due to eruptive action between them and the Laurentian gneiss. Mr. Lawson gave them the name Coutchiching, not including in them the basic eruptive rock associated at this horizon, and this survey, about the same time applied to them the name Vermilion, but included in them all the eruptive basic rock which appeared to grade off into dark and hornblendic schists and to micaceous schists. By Mr. Lawson this eruptive belt is considered as of later date than the schists, and perhaps as late as the Kewenawan, but by the writer it is regarded, so far as seen in Minnesota, as having actually preceded the crystalline schists, and really to be the most obtrusive agent in the introduction of the lithology that characterizes the crystalline schists. The principal eruptive rock was the acid Laurentian gneiss, according to Lawson, but according to this survey it was the basic doleryte.

There are minor differences, such as that touching the eruptive nature of gneisses, the later date of the Laurentian, the character of the thin, interleaved, gneissic strata between thin sheets of mica schists, sometimes reaching 100 or more alternations, and others, which will furnish subjects for future research. But the general concord, in the main results, between the conclusions of Mr. Lawson, and those expressed already, in this report, on the succession of the principal steps in Archean stratigraphy, is certainly a cause of satisfaction, and gives corroborative evidence of the correctness of the conclusions arrived at.

It is not necessary to make comparisons between these results and those of New England geologists. There is not sufficient evidence yet that the New England crystalline rocks can be assigned unexceptionably to the Archean. It has not escaped observation, however, that there are many general concordances. Especially is this true of the report on the New Hampshire crystalline rocks by Prof. C. H. Hitchcock. It is believed by the writer that the same strata extend, with characteristic l ology, through the Archean terranes of New England, and t they will be identified by and by with all the necessary dence.

REPORT OF H. V. WINCHELL.

III.

REPORT OF FIELD OBSERVATIONS MADE DURING THE SEASON OF 1888, IN THE IRON REGIONS OF MINNESOTA.

By H. V. Winchell.

The object of this report is simply to place on record the facts observed and noted during the summer of 1888 regarding the geology of the region east of Tower, paying particular attention to the iron ore deposits. During the months of July, August, September and October an attempt was made to visit all the outcrops of iron ore east and south of Ely, for the purpose of making notes, collecting specimens* and learning the relation of the ore to the rocks of the region, as well as its extent and probable value. In many cases reported by explorers and so-called "experts" it was found that their accounts either exaggerated greatly the amount of iron ore to be found at any specified place, or else that there was no iron ore there at all—nothing but iron-rusted rocks or beds of heavy dark dioryte, or even no signs of iron at all.

Region traversed. The first month was spent in examining the magnetic ore belt which lies along the north edge of the gabbro and the south side of the Giant's range. A party consisting of the writer and Mr. W. D. Willard, of the State University, with Indian packers, went overland from Birch lake to the Duluth and Iron Range railroad along the Giant's range, making frequent cross-sections of the rocks and examining all the workings in the magnetite prosecuted there in past years. After returning to Birch lake the same belt of ore was followed northeastwardly into Twp. 63–10 on the Kawishiwi river.

During the remainder of the season the party led by Mr. Uly. S. Grant, assisted by Mr. A. D. Meeds was also engaged on the investigation of the iron ores. A trip southward to lake Superior was taken through an unexplored part of the country, and the various lakes along the route were examined. The parties then proceeded to Gunflint lake and worked for a month southwestwardly. Mr. Grant's party made two or three extended trips to the south for the purpose of visiting reported iron locations, reaching Brule lake and lake Alice and making notes on the geology of their shores. The other party followed the northern edge of the gabbro to connect with the observations made from Birch lake northeastward, closing by examining some of the jasper and ore beds in the vicinity of Snowbank lake.

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*The specimens collected by H. V. Winchell are numbered in pink shellac and alcohol, and have the letter H following the numbers.

All the outcrops of magnetic ore that could be learned of were visited,—with the exception of one or two remote places difficult of access and which were in all probability in the gabbro. Also a great many exposures of hematite were examined and many new facts obtained regarding its occurrence and relations to the surrounding rocks.

The importance assigned by many of the explorers to a small bed of jasper, or jasperoid rock in the crystalline or earthy schists, is often amusing. On the strength of such a discovery they will recommend the purchase of extensive tracts of land and the operation of a diamond drill on the spot or in the vicinity; being certain that the presence of the jasper—not always even *in situ*—is a sure indication of the proximity of a valuable body of ore. They do not seem to realize that jasper is not iron ore and that a mountain of jasper is no sign, in itself, of iron ore any more than of any other mineral.

Another erroneous idea which has gained prevalence is that a bed of ore is sure to improve the farther it is followed toward the center of the earth. The contrary is often true, and it is evident that while the grade of the ore *may* improve and the quantity of it *may* increase with the depth of a shaft, yet there is no reason to expect such a thing. Therefore it is a poor investment to buy land—or rock—which contains a small per cent of iron on top, and base hopes of a paying investment on the expectation of finding it to be high grade ore 50 or 100 feet from the surface.

It is surprising what credit is given by capitalists to any man, who, with no knowledge whatever of mineralogy or geology, and therefore no judge of the probability of finding ore in a certain locality, has, however, the assurance to tell them that there is iron in such and such a place if they will only put in a shaft and "open up the mine." On the strength of such recommendations as these thousands of acres of land have been bought at a high price, which are utterly destitute of iron ore and are, perhaps, nothing but cedar swamps or hills of bare rock; and in many places there are abandoned pits and machinery where not only shafts but fortunes have been sunk in hasty and profitless prospecting and blasting. The machinery and supplies have been "packed" thither at great expense, and men employed at high wages to dig for iron when a person who is at all acquainted with the geology of the region would have told in a short time that there was no use whatever in spending a cent. In two or three places shafts were seen sunk in greenstone where there was not the slightest indication of iron nor even a bit of jasper to mislead the anxious searcher for wealth; all because it was "on the iron range."

Such hasty, ill-advised proceedings always serve to bring a region, no matter how valuable in reality, into disrepute, and to weaken the confidence of capitalists all over the country who attribute these losses and failures to the wrong cause and are, therefore, deterred from investing their own capital in the really valuable and profitable localities.

But however much money may have been hopelessly squandered in the search for iron in barren regions, yet a great deal has been employed in the development of new and rich iron deposits during the past year. The D. & I. R. R. has been extended 25 miles to Ely, south of Long lake, from which place were shipped 1,200 tons of ore daily for about two months of last season. This ore all came from the Chandler mine, which has put in a fine plant of machinery and hoisting apparatus and will be ready for much larger shipments next year. The Pioneer and Zenith mines will also be in a condition to produce a large amount of high grade ore in 1889. These mines are located east of the Chandler at Ely. At several other places in the same vicinity large crews of men have been at work uncovering and opening up promising deposits of iron ore.

There has also been some attention paid to the Animike magnetite, and in several places around Birch lake shafts and drillings have been made. None of these, however, seem to have met with success, as the ore is not found in paying quantity.

More extensive ore-beds have been found west of Gunflint lake in Twp. 65–4 than elsewhere in this formation. Work will be commenced in this region as soon as railroad facilities can be obtained. In the following notes each of these outcrops and workings is described in detail.

Principal varieties of iron ore. It is well known by those familiar with the geology of northeastern Minnesota that there are three principal kinds of iron ore. These are found in connection with three different formations. The first kind is red hematite which is found interbedded with jasper in folded and crumpled beds that occur in what has been called the Keewatin formation. This is the ore which has been mined so extensively and is in such demand by the manufacturers of steel using the Bessemer process. Many analyses have been published heretofore. The second kind is a fine-grained glistening magnetite which is generally found in nearly horizontal beds of quartzyte supposed to be a part of the Huronian formation. This is the ore which was first worked before the Vermilion lake ore had been thoroughly tested or investigated. It has not been found in quantities sufficient to pay for mining until quite recently when large beds of it, west of Gunflint lake, have been penetrated by diamond drills. This is a high grade ore and contains no titanium. An analysis of a specimen from N. E. ¼ sec. 23, 60–13 gave the following, according to Mr. C. F. Sidener:

	Per cent.
Silica, SiO_2	11.89
Alumina, Al_2O_3	.34
Magnetic oxide of iron, Fe_3O_4	87.00
Lime, CaO	.20
Magnesia, MgO	.80
Titanium, Ti	None
Phosphorus, P	.056
Sulphur, S	Traces
	100.246
Metallic iron, Fe	63.07

The third variety of iron ore is also magnetite. It is coarse and has a duller lustre than the Animike ore and is not so strongly magnetic. It is found in many places in the gabbro, which sometimes contains so much of it that it seems to be pure magnetite. This ore almost always contains a large amount of titanic acid which ruins it for merchantable ore, with only present methods of reduction. Immense deposits of this titaniferous ore are found, and most of them have been purchased from the U. S. government in the hope of being able to conduct remunerative mining operations. When a method for reducing titaniferous ores cheaply is discovered such iron ore will be valuable; but until then it is worthless.

An analysis of a sample of this ore from sec. 36, 63–10 as reported by Mr. C. F. Sidener is:

	Per cent.
Silica, SiO_2	11.37
Alumina, Al_2O_3	1.32
Magnetic oxide of iron, Fe_3O_4	53.33
Protoxide of iron, FeO	14.42
Oxide of titanium, TiO_2	16.03
Lime, CaO	.10
Magnesia, MgO	2.73
Phosphorus, P	.01
Sulphur, S	Traces
	99.31
Metallic iron, Fe	49.40

These are the principal kinds of ore. But there are various modifications and combinations of them which would not come strictly under any one of the three heads. There are, for instance, magnetite beds in the Keewatin; sometimes mixed with hematite; sometimes all magnetite. On the other hand there is hematite and even limonite in the Animike; and there are extensive fragments of the Animike formation inclosed in the gabbro which thus appears, on a hasty examination, to contain non-titaniferous, fine-grained magnetite. The gabbro is thus found to be the only rock which always contains the same kind of iron ore—(titaniferous ?) magnetite.

GIANT'S RANGE.

The first work of the season was done, as above stated, on the syenite range south and southwest of Birch lake. The trail which leads from the lake to the Duluth and Iron Range R. R. starts from the sandy bay in sec. 32, 61–12. It runs nearly south for two or three miles after becoming established. It is a poor trail but grows better as the railroad is approached. South from Birch lake the country rises rapidly, and the aneroid indicated a hight of 225 feet at a point a mile and a half from the lake. Ridges composed of drift containing syenite boulders are crossed until in the S. W. ¼ sec. 8, 60–12 a ridge of massive syenite rises quite suddenly over 200 feet more. This is the Giants' range, 480 feet by aneroid above Birch lake. Before reaching the ridge some huge boulders of syenite and dioryte are seen. This ridge is here composed of coarse reddish syenite containing much blue, chalcedonic quartz in grains one-quarter of an inch in diameter. The pink orthoclase is frequently porphyritic. The hornblende is somewhat decayed in all the specimens observed, probably because they came from near the weathered surface. Samples of this rock are 357.

The drift on the north side of the ridge is reddish and contains many boulders. On the south side of the syenite ridge the land is from 100 to 150 feet lower than the summit of the ridge. Some immense boulders are seen.

At ¼ mile south of the S. E. corner sec. 7, 60–12 there are seen numerous angular fragments of olivinitic magnetite projecting through the moss. These pieces contain thin strata of good iron ore; they seem to lie just on top of the solid rock and to have been moved from their original place by the action of frost. Samples are numbered 358.

The trail leads through a swamp for the next half mile. Just north of the small creek which crosses the line between secs. 17 and 18, 60–12 there is an exposure of solid rock. It lies in strata which dip S. S.E. 10°–12°. The rock is olivinitic and contains considerable magnetite both as a constituent of the rock itself and in veins which coincide nearly with the direction of the bedding. This rock looks much like a quartzyte but contains a large proportion of olivine. Samples from here—S. W. ¼, S. W. ¼ sec. 17, 60–12—are 359. The rock is fine-grained and greenish; it is overlain by a very light covering of drift.

Rock similar to the last is exposed in places as far south as the E. quarter post sec. 19, 60–12. The needle dips about N. 50° over this entire distance.

In the N. E. corner of sec. 19, 60–12 is a shaft about ten feet deep. Indian John Beargrease says it was dug about 14 years ago by Peter Mitchell. After penetrating about five feet of drift the bed rock is encountered. It is the same greenish, olivinitic quartzyte containing magnetite. The needle dips N. 57°. Specimens from here are 360. Some of this rock is slaty; 361.

Another shaft has been made in N. W. ¼ of N. E. ¼ sec. 19, 60–12. The rock here is quite similar to the last; some of it is very thin-bedded. A sample from this shaft showing fine stratification is 362. There is very little good ore visible here, though the needle dips 90°.

A smoothed, black exposure of ferruginous quartzyte several acres in extent, appears on the surface of the ground in the N. W. ¼ of N. E. ¼ sec. 19, 60–12. The rock and magnetite both eather shiny black, and the metallic lustre gives one the idea at he is standing on a hill of pure iron. Sample of good ore om here is 363.

In the N. W. ¼ sec. 19, 60–12 there is a ridge composed of yenite boulders three to ten feet in diameter. This ridge is 50 et high and extends for half a mile at least running nearly ast and west. It is wonderful to see these immense rounded asses of syenite (one boulder of quartzyte was seen among em) piled up on top of each other with crevices ten or fifteen et deep between them. No rock is seen in the woods on the uth side of this ridge, with the exception of a few boulders. his moraine seems to lie just south of the magnetic quartzyte.

Iron lake. This small lake is one of the few bodies of water at lie south of the summit of the Giant's range and yet nearly elevated as the range. It is situated in secs. 13, 14, 23 and 24, -13. Its shore is surrounded by boulders, mostly syenite, from e ridge north of the lake. There are also, however, many angular eces of magnetitic quartzyte. This rock contains less olivine re than a few miles further east. A few boulders of a quartz nglomerate with a green matrix were seen on the east side of e lake in the N. W. ¼ sec. 24, 60–13, No. 364.

A short distance east of the lake, in the N. W. ¼ sec. 24, 60–13 e bed rock was exposed in the hillside by a windfall. It is the ual black, magnetitic rock lying in nearly horizontal strata. me of the rock here is reddish and jaspery; there is also a con- omeritic aspect in places. Sometimes the rock is slaty in in, black, parallel strata that are quite straight for a rod or ore. Again the iron seems to be in veins which do not conform ictly to the general planes of stratification. The following t is from the perpendicular face of a ledge in N. W. ¼ sec. 24, -13.

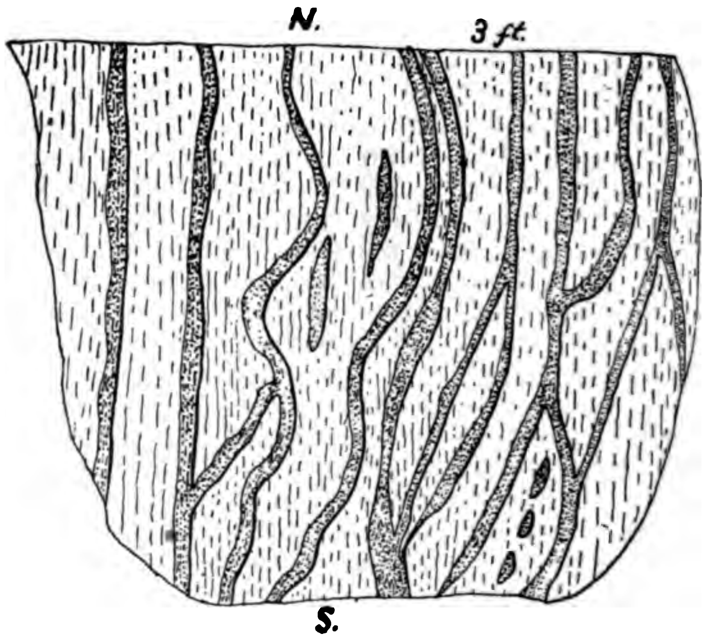

Fig. 1.—*Veins of magnetite in greenish Animike rock.*

A short distance N. W. or N. of last the ledge is exposed in a perpendicular wall 8 feet high and a couple of rods long. It is in thick black beds that have a high specific gravity and are crystalline with a dark mineral that may be hornblende, No. 365.

Near the north end of Iron lake, in S. W. ¼ sec. 13, 60-13, the magnetitic quartzyte undergoes a queer metamorphosis. It still lies in nearly horizontal beds; but it gradually becomes less highly charged with magnetite, acquires feldspathic and quartzose materials and finally is changed to a regular, reddish crystalline rock which is the syenite of the Giant's range. The lowest beds are the most perfectly crystalline. Before the transition becomes complete the Animike rock appears to be feldspathic in spots as if there were boulders of syenite in it, but lower down the beds become wholly syenitic. The quartz grains that are first seen in the greenish Animike rock have the same bluish translucent appearance as those in the syenite which lies just north. This change is illustrated by specimens numbered 366.

The quartz grains are seen before the feldspar. There are also tions of the Animike which are conglomeritic and are the ne as the peculiar conglomerate, 364. A sample which conns part of a felsitic boulder is 367. The dip needle is but ghtly affected here.

North of Iron lake the land does not rise suddenly; but there gradual upward slope for about half a mile when the summit the range is reached and there is an abrupt descent of 200 feet more. Syenite containing a little biotite is seen in the bluff the north side of the range. One sample from the N. E. ¼ . 14, 60-13 is 368.

There are no exposures of solid rock on the N. W. side of Iron ke. On the S. W. side in the N. E. ¼ sec. 23, 60-13 there is a lge of black magnetic rock, 369. It presents the usual charteristic aspects of this formation; lying in nearly horizontal ata and containing more or less magnetite which gives a dark lor to the rock.

Iron lake is nearly as elevated as the summit of the Giant's nge. The black rock on the north side of the lake is close ove the syenite; and the change which was observed to have ken place must be mainly in the nature of a fragmental transin rather than a metamorphic one, i. e., the gradual increase thin the Animike of the feldspathic and quartzose materials st be due to the fact that there was more or less debris derived m the crystalline ridge on the north which was covered up by e Animike deposits and by subsequent metamorphism incorrated closely into them. That this metamorphosing process s in the nature of a slow rearrangment and reuniting of the ineral constituents rather than of a violent and more sudden sturbance seems to be indicated by the comparatively undisrbed position of the strata.

Mr. Willard went south from the lake through the S. W. ¼ c. 23, and the W. ½ sec. 26, 60-13. He reports fragments and outcrops of the dark iron ore rock all the way to the swamp the N. W. ¼ sec. 35, 60-13. Sample from that locality is 370. is tough, black, heavy rock and contains probably 45 per nt (?) of iron.

The percentage of iron in the rock appears to grow less going stward from Dunka river; toward the northern edge and westrd there is also less olivine and more quartz. Fragments of d jasper are seen all along the trail. These may have been nsported from north of the Giant's range, although red jasper d quartzyte have been seen in the Animike formation in this region. Pieces of porphyritic rock that look as if they belong to the same formation near its contact with the syenite are also seen along the trail.

Some pure quartzyte containing, however, a small amount of magnetite, is found in angular fragments. A sample of reddish-gray quartzyte from N. W. ¼ sec. 32, 60–13 is 371.

The bed rock is seen to be just beneath the moss and light drift covering for two or three miles in sections 28, 32 and 31, 60–13. Ridges composed of granite and syenite boulders are seen at intervals, and evidently form part of a morainic system. The drift deposits become thicker toward the west.

Just south of the trail in S. W. ¼ of N. W. ¼ sec. 32, 60–13 is a large exposure of the semi-crystalline fragmental rock which intervenes between the regular Animike and the syenite, and grades into the latter. This rock is exposed here to a depth of 12 or 15 feet. At the top it contains considerable green, uncrystallized material, and the feldspar crystals are not so well formed as farther down where there is less of the green matter. There is an indistinct gneissic structure which seems to lie nearly horizontal; there is also a coarse schistosity which runs N. E. and S. W. At the top is a conglomeritic layer which contains pebbles of quartz and some of greenish rock, some of them two inches long, but mostly less than an inch in length, No. 372.

The rock at the bottom of this exposure is almost wholly crystalline with the usual constituents of syenite. The hornblende crystals are the last to be developed; large crystals of feldspar appear in the green matrix before it begins to show any other signs of crystallization. These feldspar crystals are orthoclase and are sometimes blood-red.

Peter Mitchell uncovered the iron ore beds in several places in the S. W. ¼ sec. 32, 60–13. Some of the rock thus exposed is quite slaty, 373. The shaft in the S. E. ¼ S. W. ¼ sec. 32, 60–13 is about 8 feet deep. It penetrates solid, black rock containing magnetite in grains and poorly defined layers or bands all through it. It is poor ore. On the surface a short distance northwest of the shaft the rock is more unevenly bedded and consists of thin veins of black ore in a gray rock. No. 374. The needle dips at all angles in a very small radius here. Glaciation is about N. N. E. Some of the rock is fine and jaspery with a reddish tinge, No. 374 A.

This is in a low ridge trending N. E. and S. W. or thereabouts. Sometimes similar ridges are seen made of boulders, l sometimes of syenite. In the S. W. ¼ sec. 31, 60–13 is a all ridge composed of iron ore rock. It has been broken off l the land east and north is lower. The east face of the ledge mooth and vertical and can be followed for half a mile on the rth side of the trail. The grayish, quartzose rock lies in arly horizontal beds, all of which contain magnetite. This ck always weathers shiny, smooth and black and has the pearance of solid iron. There is very little pure ore in these ds. A sample from the S. W. ¼ sec. 31, 60–13 showing the athered surface is 375.

There is a large exposure of the Animike rock and a shaft g down about ten feet by the side of the vertical exposed wall rock in the N. E. ¼ sec. 11, 59–14. There is here seen a ckness of 15 feet of the usual dark-colored rock. It is, however, reddish in streaks and contains a little hematite with the gnetite. At the bottom of the shaft, particularly, the rock oft and hematitic. At the surface of the ground the rock is rder and seems to be composed of reddish quartz in fine grains ongly resembling the "chalcedonic" quartz of Vermilion e, 376. Hematitic rock from the base of the shaft is 376 A. ere are thin bands of good ore contained in the rock here; t there is not enough to pay for working. This ledge is on west side of a ridge which trends to the northwest. The ata have a little higher dip than usual toward the southeast. me of the ore is seen to be further altered to limonite.

In the N. W. ¼ sec. 11, 59–14 is a small outcrop of Keewatin k.* It lies in vertical beds striking N. 80° E. Sample is I. In the S. E. ¼ of the same section and particularly in the E. "forty" there is a great deal of this rock. It rises in a lge 15 feet above a cedar swamp. It is feldspathic or felsitic d stands in vertical strata having the usual strike for this mation. Samples are 378.

Prof. A. H. Chester, in the Eleventh Annual Report Geology Minnesota, p. 156, speaks of hematite boulders in a layer of ck sand, which he observed at the bottom of a shaft 15 feet ep in Animike, a short distance north of here. Perhaps they re on top of the Keewatin and were covered up by the Anike sediments.

The Animike beds appear to be considerably broken in this gion. Several very large masses of strata were seen that were in horizontal position and evidently but slightly disturbed from their original position. Some of them are on the hill above the Keewatin and only about 200 feet away from exposures of it in the S. E. ¼ sec. 11, 59–14. There seems to be no reason to doubt that the black iron ore rock lies horizontally and unconformably on the upturned edges of the Keewatin. We dug a shaft by the side of a large, flat-lying mass of Animike here. It was not proven to be certainly *in situ;* but had evidently been but slightly disturbed. In this same section in various other places Animike in place is found lying above exposures of Keewatin quite near, but no actual contact was seen.

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*This is believed to be the first observation reported of the existence of the green schists is formation south of the Giant's range.

There is another shaft in the iron ore rock in the N. W. ¼ sec. 14, 59–14. It lies nearly horizontal and the rock has the usual gray, arenaceous, magnetitic appearance. It is glaciated on the surface but the direction could not be taken owing to the magnetic disturbance. One sample from here is 379.

The black slates and quartzytes in sec. 22, 59–14 do not seem to be so magnetitic, but contain veins or bands of blackish quartz or jasper. This jasper is granular and upon being pounded it crumbles and displays many white grains. The rest of the rock is grayish and is penetrated by fine needle-shaped crystals of hornblende (?) No. 380.

In the S. E. ¼ sec. 17, 59–14 there is an outcrop of the schist which is supposed to be Keewatin. It is in vertical beds which strike N. 75°—N. 80° E. It is dark gray and soft but siliceous and sericitic, 381. This is only about one mile south of Hinsdale and is remarkably close to the syenite ridge which rises 150 feet or more higher, a mile north of this exposure. The syenite appears only half a mile north of here. The dip of the schists is vertical or at a high angle to the south.

The rock which forms the highest part of the Giant's range at Hinsdale is syenite which frequently has a distinct vertical gneissic structure. This syenite is reddish near the surface, but is gray about 30 feet below. It contains porphyritic crystals of pink orthoclase, which become deep red in places. There are lenticular masses of dark, hornblendic rock inclosed in this syenite at all depths. Some of these inclusions are five or six feet in diameter. They are always elongated perpendicularly and consist generally mainly of hornblende, 383.

A few intrusions of fine gray granite and pink granulyte are seen to penetrate the syenite. Epidote colors the rock in the proximity of veins and faults or fractures. Quartz and feldspar veins of limited extent are not uncommon.

The rock is a handsome one for ornamental purposes, and columns or blocks of any required dimension quite devoid of flaws or cracks can be obtained. It has been quarried for the manufacture of paving stones. It is also being employed in the erection of the Round house of the D. and I. R. R. at Two Harbors. Twenty-five samples of this rock were obtained, 382. Glaciation is very fine on top of the ridge, N. 22° E. The summit of the range is 120 feet by aneroid above the station at Hinsdale.

North of Hinsdale there is a rapid descent in the level of the country. At one mile and a quarter from the station is a low outcrop of syenite. It is quite similar to that in the ridge. It outcrops again at 2 miles and still again at about 3 miles north of Hinsdale station. At the last place it is red and dark and the hornblende is decayed. Small geodes of quartz and calcite crystals are seen in it here. One sample is No. 385. The level here is 180 feet below the top of the ridge at Hinsdale. There is considerable drift mixed with numerous boulders of syenite at this place and all along back to the ridge.

The last syenite seen on the railroad north from Hinsdale is about five miles from the summit of the Giant's range. It is reddish and lies in low outcrops. For the next mile or two the country is low, flat and swampy. Then come knolls and ridges of Keewatin dipping about N. 75°. The dip is lower than on the south side of the ridge or at Tower. Veins of calcite are noticed in the rock.

It is noticeable that no Animike either in place or as boulders is seen north of the Giant's range. The ridge of syenite is about six miles wide from north to south where the railroad crosses it.

John Mallmann in charge of a crew of 25 men was at work in sec. 29, 59–14 sinking shafts through the drift and down to the underlying rock in search of iron ore. He finds the rock to contain both hematite and magnetite. Some of it is colored quite red by sesquioxide of iron. At depths below the surface varying from 15 to 40 feet the bed rock is encountered. It consists of thin strata of grayish rock which might be termed ferruginous quartzyte, but it is not pure quartz and iron ore. Some of it has an indistinct conglomeritic appearance, the pebbles being fine, grayish or greenish or sometimes hematitic. The beds are not as a rule more than 6 or 8 inches thick and have a low dip to the south or southeast. The syenite is said to lie about ¼ mile north of here. Much of the hematite found in these shafts shows a further alteration toward limonite.*

Red, hematitic rock having the usual dip and appearance of hematitic Animike strata is seen in a shallow railroad cut about ¼ mile south of Mallmann's camp.

Mr. Willard visited Partridge river and examined some exposures of rock in the neighborhood. Gabbro was seen in a railroad cut ¾ mile north of Beaver creek, sec. 5, 58–14. It was exposed for 150 feet along the track. It was somewhat decomposed and weathered into rounded, boulder-like forms, 384. One-quarter of a mile farther south is another cut through gabbro. The same rock is seen on the south side of Beaver creek about a hundred paces from the railroad track, and in fact forms all of the knolls and is seen in all of the cuts for some distance south of Beaver creek.

On the south side of Partridge river, about in the N. E. ¼, S. W. ¼ sec. 9, 58–14 just above a small creek is a low outcrop of black or dark-gray, siliceous, thick-bedded slate which seems to dip about 20° N., 80° E. A system of vertical joints pervades this rock, the general direction of which is about east and west. About 200 feet down stream from here the river runs over the edges of these beds of slate. Following the rock for some distance down stream an old shaft is seen but no interesting features are exposed by it. It is in a ridge whose course is nearly north and south. Exposures of this same rock were noticed in several places in this vicinity; the ledges rising about 8 feet above the general level. The gabbro overflow surrounds and nearly covers this rock. The strike of the slates where the strata have been broken or lie in ridges for any distance, is N. 10° W. This rock is not exposed over a region exceeding 350 feet in diameter. It seems to be a little of the Animike formation which was not

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* An analysis of this limonite, made by Mr. C. F. Sidener, gave the following:

Silica, Si O_2	3.52 per cent
Sesquioxide of iron, Fe_2O_3	87.10 per cent
Manganese	traces.
Lime and Magnesia	traces.
Phosphorus, P	.023 per cent
Sulphur, S	traces.
Water, H_2O	9.70 per cent
	100.343
Metallic iron, Fe	60.97 per cent

covered by the gabbro overflow. It is not iron-bearing here to any appreciable extent as are the strata generally farther north. It occurs in thick, homogeneous beds in which the sedimentation is quite evident. It is silico-argillaceous and seems to be carbonaceous. Samples are numbered 387. The rock lies in lower ground than the surrounding gabbro knolls, between which and the slate a swamp intervenes.

In the N. E. ¼ of the S. E. ¼ sec. 11, 59–14 is a shaft five feet deep. No rock *in situ* appears to have been encountered in it; but many fragments of reddish-gray, quartzose rock are seen in the sides of the shaft and on the surface round about. This land is 140 feet lower than that ¼ mile north of here. Samples of reddish hematitic ore from here are 388.

About 250 paces west of the east quarter post of sec. 11, 59–14 is a shaft dug to a depth of ten feet by the face of a north and south ledge of rock. The strata here dip about 15° slightly to the south of east. Good iron ore is seen in veins or bands 2 or 3 inches thick in the face of this ledge. This wall of rock is exposed for several rods north and south of this shaft. It is noticeable that the prevalent direction of the joints in this formation is north and south.

In a part of sec. 11, 59–14 which was visited on our return to Birch lake, near the center of the section, Keewatin rock is found standing as usual in vertical strata. It is quite feldspathic. Above it, separated by a few feet only of unexposed rock covered by drift, are masses of Animike strata 15 feet long and 8 feet thick which seem to have been but slightly disturbed from their original position. A sample of the Keewatin rock is 389. There are quartz veins in it which contain talc-like scales. 389 A. Some of this vertical schist is graywackenitic and some granulitic. Some resembles the rock found at Partridge river supposed to belong to the Animike, 390.

Outcrops of felsitic, siliceous schist in vertical strata with a strike N. 80° E. are seen in N. E. ¼ sec. 15, 59–14 near the north section line; 391.

Southeast from the last about 200 paces and 40 feet higher is found a large solid outcrop of iron ore rock. It rises five or six feet and is seen for four or five rods. It is horizontally stratified or has a dip of less than 10° to the east. This is considered as certainly lying unconformably on the vertical Keewatin. No. 392 is from here.

There is another ledge of iron ore rock (Animike) in N. W. ¼

N. W. ¼ sec. 14, 59–14 near the center of the quarter section. Some good ore is found here, 393. From the way in which the Keewatin schists are found to underlie all this Animike an observer receives the impression that an iron mine or iron lands in this formation *here* are not of much value, for it is doubtful whether a shaft 40 feet deep could be made in the iron ore rock anywhere in this township without passing through it and reaching the Keewatin.

Fragments of the Keewatin rock are seen all along the trail in Twp. 60–13, indicating that it outcrops somewhere and perhaps at several localities between the trail and the syenite ridge. The number of rough pieces of Animike rock that are everywhere seen along this trail show what was the entire surface of the land south of the Giant's range and indicate that the region immediately south of the ridge was to a great extent protected from the force of glacial erosion.

A sample of quartzyte which was seen in angular fragments in 60–13 was obtained as showing fine stratification. It contains a little magnetite in bands which fade out completely in this specimen. No. 394. Deposits of magnetic sand are seen on the shore of Birch lake where the trail starts out, S. W. ¼, S. E. ¼ sec. 33, 61–12. No. 395.

BIRCH LAKE REGION.

Tonga or Dunka (*sand*) *river*. This name is bestowed by the Indians on account of the extensive banks of reddish sand and gravel which form the shores of the lake near the mouth of the stream and also compose the bed of the river for a short distance above the lake. Mingled with this red sand is more or less black magnetic sand sometimes in such quantity as to make the beach black. An instance of this is in the S. W. ¼ sec. 33, 61-12.

For a mile up this river there is a large amount of drift containing many boulders. The land rises in east and west ridges 100 feet or more above the river. Near the south side of sec. 4, 60-12 the ridges seem to be composed almost wholly of large granite and syenite boulders. It can not be ascertained certainly whether they are underlain by rock of the same nature *in situ* or not.

South of this ridge is another in S. ½, N. W. ¼ sec. 10, 60-12[*] which has, exposed on the surface, many angular fragments of a knoll of syenite. The latter is porphyritic with pink and white feldspar and contains both biotite and hornblende, together with a considerable proportion of quartz. It rises in the knoll as high as the top of the quartzyte ridge but slopes down and runs under it. The syenite is 400. The quartzyte is in beds which are nearly horizontal and seem to have about the same texture and composition where it lies on top of the syenite as they have ten feet higher up, 401. A claim cabin is located on the syenite ridge only a few rods from the quartzyte ledge. The syenite is cut by a few veins of fine, pink granulyte. The situation is shown in Fig. 2.

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[*] This ridge is referred to by N. H. Winchell, in his fifteenth annual report, p. 341.

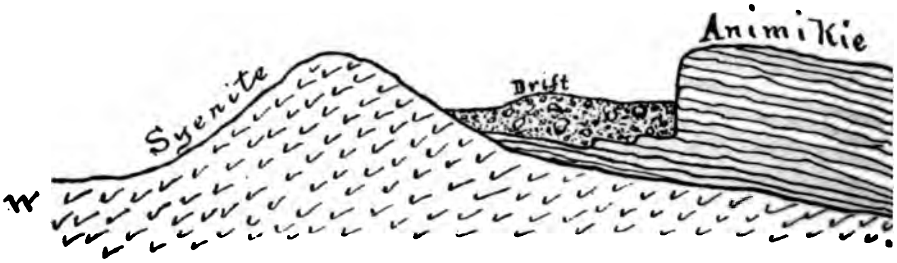

Fig. 2. Relation of syenite and Animike ridges. The little valley between the two ridges is about 12 feet deep and 35 feet across. The west face of the quartzyte is perpendicular. The land is covered with small pines.

A trench was made with some labor from the quartzyte to the syenite thus exposing the manner of contact. The Animike was found to lie on the syenite in a thin, hard, hornblendic stratum about six feet from the main mass of exposed syenite. It was buried under about five feet of till with hardpan at the bottom. Samples of the layer of Animike rock found lying on the syenite are 406.

In the first shaft that was dug down at the foot of the Animike bluff a large mass of greenish Keewatin rock was encountered that prevented further excavation at that place. This rock, which was supposed to be a drifted fragment, was coated with a crust of calcite crystals all over the top. In several places the syenite was seen to have a thin layer of the hardened Animike rock adhering to it which had not been removed by glacial scraping. From the appearance of such rock it seemed as though the abrading action of the ice was not so violent as is generally supposed.

In the N. E. ¼ of S. W. ¼ sec. 35, 61–12 the magnetitic quartz-granite and gabbro and are estimated to be 150 feet above Birch lake. A thickness of about 25 feet of the iron-bearing strata was seen in the various shafts.

This same rock outcrops on the west side of the little bay in S. E. ¼, S. W. ¼ sec. 24, 61–12, a short distance back from the shore. At this place it is much decayed and jointed.*

Vicinity of Kawishiwi river. Going south on the range line between townships 62–10 and 62–11 on the south side of the river in S. E. ¼ sec. 13, 62–11, search was made for the iron ore reported by Mr. Lorenzo Cleaves. Nothing was found for half a mile except syenite in a ridge about 75 feet, by aneroid, above the river. Then there is a swamp and a creek, and gabbro hills are reached in S. W. ¼ sec. 19, 62–10. These hills are but a little over 100 feet above the Kawishiwi. The gabbro is seen in bare knobs and vertical bluffs 20 to 40 feet high. Some masses of gabbro 30 feet in diameter have been pushed up on top of the smoothed knolls of solid rock and left there by the ice.

In the S. E. ¼ sec. 30, 62–10 are several shafts, some more than 20 feet deep, in magnetite ore. The magnetic attraction is very strong here and the needle dips 90°. There being more than a mile and a half of gabbro north of this place and this iron ore itself being in hills of gabbro 100 feet high it would naturally be supposed that this ore is gabbroitic magnetite and therefore titaniferous.

But the ore is olivinitic and generally quite fine-grained, and the rock which contains it is not a massive crystalline rock like gabbro, but stands in beds which are nearly vertical, though the dip is not constant. These strata are olivinitic and besides being finely granular, possess a banded structure and are evidently *transported beds of Animike strata contained in the great gabbro overflow.* Whether they are between overflows of different dates or were surrounded and taken to their present position at the time of a single eruption was not evident, but the latter is more probable. The gabbro itself being also largely composed of magnetite here renders it more difficult to distinguish between the two kinds of rock. Samples from the S. E. ¼ sec. 30, 62–10, showing banded structure supposed to be due to sedimentation are 407. Specimens of the coarse gabbro magnetite are 410. The Animike is quite hornblendic here as at the locality north of Birch lake, sec. 24, 61–12. The gabbro which forms massive knolls all around this place is not so much decayed as the iron quartzyte, nor does it display any banding nor any other signs of bedding as do the enclosed strata of Animike.* The general strike of the latter is east and west.

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* N. H. Winchell, Fifteenth annual report, p. 335.

A trip was made from the Kawishiwi river in N. W. ¼ sec. 25, 63–10 southeastward into sec. 36. Gabbro ridges and knolls from 70 to 100 feet above the river are crossed. Many large fragments of greenish schist from farther north lie on the surface, also boulders of syenite and amphibolyte or dioryte. This gabbro is rather coarse and is magnetitic in spots and streaks; 412. There are belts of coarse hornblende and labradorite found in it. 412 A. Included in the gabbro are irregular masses of all sizes of fine, grayish rock that seems to be composed of rounded grains and resembles Animike. There is no evidence left of former stratification, and in places where it has been highly altered this rock has the composition of a fine gabbro. But the transition from it to the gabbro is always abrupt and the outlines of the included masses of it are plainly seen. 413. This rock is slightly ferruginous if at all; but the gabbro contains much shining, coarsely crystalline magnetite. 414.

In the S. E. ¼, S. E. ¼ sec. 25, 63–10 the gabbro contains some large masses of very coarse hornblende. There are places in the gabbro four to six feet in diameter which contain or are wholly made up of black hornblende crystals six inches long. There is a little mica in connection with it, also some coarse labradorite. 415.

Vicinity of Long Lake. The hills in the N. W. ¼ sec. 20, 63–12 are composed of diabasic rock. They rise about 100 feet above

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*An analysis of the magnetite supposed to belong to the enclosed beds of Animike and therefore to be non-titaniferous, was made by Mr. C. F. Sidener. No titanium being found in it the effect of the gabbro does not seem to have been intense enough to invest the magnetite with harmful ingredients.

Silica, SiO_2	11.39 per cent
Alumina, Al_2O_3	Traces.
Magnetic oxide of iron, Fe_3O_4	85.55 per cent
Titanium, TiO_2	None.
Lime, CaO	.22 per cent
Magnesia, MgO	3.44 " "
Phosphorus, P	.02 " "
Sulphur, S	Traces.
	100.62 " "
Metallic iron, Fe	61.95 " "

the lake, and in them are seen the same coarse boulder forms* as have been noticed in this rock farther east, also at the railroad cut near the Chandler mine, on the south shore of the lake in sec. 28, and in the N. E. ¼ sec. 5, 62-12. On the north side of the first ridge north of the lake the rock is not so diabasic, but is the usual more or less fissile sericitic schist.

In the N. E. ¼ sec. 9, 63–12 the sericitic schist changes rapidly across the strike, going north, into granite, becoming first siliceous, then felsitic or feldspathic and finally micaceous. Specimens illustrating this are Nos. 416 to 416 E. The granite still preserves in places a coarse vertical schistosity. North of this granite, which continues only for a short distance, is hornblendic biotite schist crossed by veins or intrusions of syenite and granite; 417. This dark schist is in vertical strata having the usual strike of about N. 60° E. The lake which lies in sec. 4, 63–12 is about 75 feet higher than the lake just south of it.

Going overland from the lake to the N. W. corner sec. 4, 63–12 the rock is found to be hornblende-biotite schist dipping north at an angle of 75° or more. Most of it is very dark colored and heavy, 418. Nothing was seen of the belt of magnetic iron which had been reported to exist in this section.

Going south from Ely into sec. 4, 62–12 the rock is found to be mostly covered by a thick deposit of drift until the N. W. ¼ sec. 4 is reached. Here there is seen an abrupt ridge of sericitic green schist striking N. 60° E. and having a vertical dip. This ridge rises 75 feet above the swamp on the north side of it. The rock contains considerable calcite as at Ely. 419. Going west several pits are seen dug in the low ground north of the ridge. All of them penetrate a soft reddish rock strongly impregnated with iron similar in appearance to that in the mines at Ely. It seems probable that the depression north of this ridge may have been produced by reason of the softer nature of the iron ore beds which may lie in there. And it is not at all unlikely that rich beds of soft ore underlie the swamp referred to. In the N. E. ¼ sec. 5, 62–12 a large, glaciated surface of the green rock is exposed. There is here a fine exhibition of the coarse agglomeritic structure mentioned above. A diamond drill just east of this place has gone down 60 feet in the same rock.

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*This is referred to by Mr. A. C. Lawson in his report on Lake of the Woods as a "concretionary (?) trap structure."

LAKE SUPERIOR TRIP.

The country south and east of Bald Eagle lake (the Indian name for this lake is *Mishiwishiwi sagaegan* or Beaver-house lake) has been burnt over and is now covered by a small growth of aspens, birch, jack pine, spruce, etc. It is rocky and hilly, the hills of gabbro rising 100 feet or more above the general level. The route to lake Superior lies up the river which enters the south side of Bald Eagle lake. This stream is smooth for a short distance and has low swampy banks. A rapid where the river falls 50 feet is then encountered and above it again the smooth, currentless stream. The solid rock is all gabbro and most of the boulders are of the same material, though there are a few boulders of Keewatin greenstone and of granite. On the first portage there are seen some large pieces of white vein quartz. The gabbro for a mile or two is almost wholly composed of labradorite. In one place was seen quite an accumulation of boulders of siliceous greenish rock like that at the west end of Knife lake.

The land in the S. W. ¼ of township 62–8 is quite uniformly level. The lake in sections 29 and 32 has low shores, mostly marshy. The rock is gabbro, many boulders of which lie around. The lake and river seem to be almost on top of the gabbro ridge, the hills around them are so low.

Lake Isabelle. The shores of the west side of this lake are composed of gabbro. They are generally about ten feet high, but sometimes rise to forty feet. The gabbro is very much decayed near the surface. It is composed principally of labradorite; but contains some biotite and a little magnetite. There are occasional small pieces of granular olivinitic rock, supposed to be Animike, enclosed in the gabbro. They are hard and sometimes have a basaltic structure. A sample of gabbro from N. W. ¼, S. E. ¼ sec. 35, 62–8 is 420. There are numerous boulders of fine siliceous greenstone from farther north seen lying around the shores of the lake. The Indians call this lake by the same name as Gabbro lake, viz.: *Kazushkonabigka-gamak*, the lake-with-the-shores-of-shelving-rock. On the east side of the point last mentioned is a beach of sand and pebbles. The latter consist of siliceous greenstones, porphyrytes, granites and gabbro, 421.

The gabbro in the bay east of this point is smoothed by glaciation and considerably decayed. It contains in one place ten feet of hard, greenish rock in a dyke or bed about a foot wide, which seems at first to be trap, but is not massively crystalline and seems to contain some rounded grains, and therefore may be Animike rock hardened by the action of the gabbro.

In the S. W. ¼ of S. E. ¼ sec. 36, 62–8 there is a dyke 16 inches wide exposed for 30 feet. It is perfectly straight and is composed of tough green rock. The dyke walls are well-defined and it maintains the same width for the whole distance of its exposure. This rock hardly appears like trap; it is too granular and not sufficiently crystalline. Neither can it be said to resemble the Animike rock. The direction of this dyke is N. 64° E. 422.

In the S. E. ¼ sec. 36, 62–8 the gabbro stretches out in long, low reefs into the lake. Beds of sand which is the result of rotting gabbro occupy the hollows. There seem to be layers or beds in this gabbro that are like the rock found in the dyke, 422. The question arises whether this rock was igneous and flowed over on the gabbro or whether it is changed Animike enclosed in it. Glaciation is N. 24° E.

Some of the gabbro is fine grained and brown and contains more biotite than the gray. Perhaps this is what has been called "muscovado." One sample from the south shore of the lake just east of the range line in Twp. 62–7 (unsurveyed) is 423.

Swamp Lake river (*Maskigo-sibi*) enters lake Isabelle on the east side. This river is a series of lakes connected by a small stream. About two miles up this stream a change takes place in the gabbro. It is found to be composed of reddish feldspar and much hornblende with a little biotite, magnetite, pyrite and sometimes galena. Streaks of this reddish gabbro are first seen running through the gray and then it all becomes red, and large massive knolls are formed of it. Nos. 424, 424 A. and 424 B. illustrate this change.

The route to lake Superior lies through the series of small lakes connected by a stream which comes from the east and southeast. This stream is very rocky and full of rapids and comes from Kaminisabikokak lake which has been re-named lake Bellissima. This lake is about two and a half miles across from east to west and four miles long from N. W. to S. E. It is situated in the southeast part of Twp. 61–7, and perhaps extends into Twp. 61–6. Notwithstanding the rapids in the river a person receives the impression that the country is unusually level. No hills of any considerable hight are seen, and at times the stream is merely a narrow lake a mile or more in length with a low pid at each end and shores not over 20 feet high. The couny has all been burnt over and the only trees are small poplar, rch, willow and jack pine. A great many boulders principally gabbro are seen on all hands. There are also boulders of trap id red Cupriferous rock for two or three miles west of Bellisma lake. The solid rock is all gabbro. West of the lake it is arly pure labradorite, but toward the east it is associated with larger proportion of magnetite. It decays rapidly and crumles apart forming beaches of sand which is nothing but decomosed labradorite feldspar. The Indian name for this lake is pplied with reference to the large number of boulders which ne the shores and stand several feet out of water at some disance from the shore all around the lake.

There are sand and gravel beaches, beaches of small cobble ones, beaches of moderate sized boulders, and beaches where he boulders average more than six feet in diameter, while some re fifteen to twenty feet. The largest boulders are of gabbro; ut many of the smaller ones are greenstone or red amygdaidal trap. There are comparatively few exposures of solid ock around this lake, but all the rock that is seen is gray gabro.

The stream which enters the southeast corner of the lake is anoeable for only a short distance, about half a mile above Belissima lake. A portage of a half a mile is then made to a small ake and then another portage of one and a half miles south to ake Gaokakag, or lake Harriet. The country has a heavy covring of drift sand and gravel and but little rock is exposed. Many of the pebbles and boulders are from the Cupriferous. Occasionally there is seen an outcrop of gabbro, quite coarse and ontaining considerable magnetite. The surface is rolling and pen, having been burnt but a few years ago.

Lake Harriet is about two miles long. It is a beautiful body f water set in hills heavily covered with white pine around he south half of the lake. High water is maintained in it by beaver dam at the outlet. The long portage necessary to make in order to reach the lake from the north cuts off an mpassable part of the river. This lake is 70 feet higher than he small lake at the north end of the portage. The country tween these two lakes is good farming land, but is now nearly re, having been burnt recently.

At the outlet of lake Harriet there is a massive exposure of dish-gray rock, which crosses the river and forms a rapid.

This rock is a phase of the gabbro. Some of it is fine and hard and very tough. It is composed of hornblende, biotite and red feldspar. A little farther south the rock is coarser and contains a small amount of gray labradorite. Then the two kinds of feldspar occur in equal proportions. From here the red feldspar fades out until the usual condition of the gray gabbro is reached. Where the fine, hard, reddish-black rock is first seen it does not look at all like gabbro. Nos. 425 to 425 C illustrate the change.

Hornblendic gabbro is seen in a low exposure not far east of the north end of the lake. No. 426.

This lake is situated in secs. 20, 29 and 28, 60–6. Very few exposures of rock are seen around it, the shore being mostly composed of the drift which supports such a fine growth of pine. Hills of drift 60 feet high surround the lower end of the lake. A few boulders are seen on the lake shores, but they are mostly sandy. There is an immense accumulation of boulders just north of the lake — large bare ridges of all sorts of boulders, trap, gabbro, Cupriferous, Keewatin, porphyry, granite and Animike slate. These ridges are evidently morainic deposits.

A short portage of 285 paces leads southeast from lake Harriet to Pine lake just east of it. Some trap and a peculiar rock of various colors and texture were seen on this lake. The notes here were taken by Mr. Grant.

A half mile portage leads across the divide from Pine lake to a small, nameless lake 30 feet lower. No rock was seen around this lake.

A long portage, over two miles, leads south to *Kapokegamak or Crooked lake*, in Twp. 59–6. The country is all covered with a fine growth of green timber. The drift is rich and evenly distributed and the land is good for farming.

In sec. 15, 59–6 some fine-grained, olivinitic gabbro was found. It is cut by extensive dykes of green trap.

A sample of gabbro which was found in place on the west side of Crooked lake is 428. Steep hills of trap occur just west of the northern narrows, sec. 15, 59–6. This trap is porphyritic with green feldspar(?). It outcrops in several spots around the lake south of here. 429. Glaciation is N. 6° E.

From Crooked lake a short portage leads south to a small nameless lake on which no rock was seen. From here a portage of one-half mile leads to Nine Mile lake, so-called because it is nine miles by trail to lake Superior and no more canoeing. On ι and west sides of this lake are exposures of rather fine-olivinitic gabbro. 430.

ing the nine mile portage trail south a distance of one ıall pond less than one-fourth mile long is encountered. 5 feet lower than Nine Mile lake. In the next half mile rises 220 feet and reaches a pond 205 feet above the last :e. Lake Superior can be seen from the hills surround-pond, which rise 75 feet above it. The land on the ›re of the great lake can also be seen with the naked is pond is supposed to be in sec. 35. 58–6.

eek which flows from the pond runs in a deep gorge. wall of this gorge is Cupriferous and the west wall is ıed olivinitic gabbro or trap. This is the first true ›us seen on this route. It rises in high, precipitous ›isting of a reddish felsitic rock very much jointed and ıg light and dark spots and streaks. Several shafts n dug at the foot of the gabbro ridge on the west side :ge mentioned above. Fragments of the reddish Cuprif-k were thrown out from all of these pits; and in fact that ›ntly the only rock found in digging them. In one of fts the red rock seems to be in place. This is just below bluff of gabbro which therefore seems to lie upon the ›us here. Still they may be side by side and neither bove the other. The gabbro contains more olivine and ıetite than that seen six miles north of this place. The ›oundary line between the gabbro and Cupriferous runs :he south tiers of sections in the east half of township ımples of the gabbro are 431. The Cupriferous is 432. ›n this high ridge and the range of hills just north of there is a low, broad valley heavily timbered. The ı not cross the highest part of the ridge along the lake ıt follows the valley of a small stream which seems to ı a gorge through the ridge, but probably followed a lepression. No rock was seen exposed south of the .dge. The trail descends 1125 feet between the small ›tioned last and lake Superior. There are hills around 1 100 feet high, and the gabbro ridge is therefore 1225 ıeroid above lake Superior, or 1827 feet above sea level. l comes out at Pork bay. The hills at the west side of :ise 330 to 460 feet above the lake.

GUNFLINT LAKE.

A small stream from the north enters the east end of the lake just north of the boundary river. A few rods west of the mouth of this creek gabbro is seen lying in Animike slates. About one-eighth of a mile up the creek rock in place is noticed. This is a ridge of vertically bedded rock supposed to be Keewatin. Strike is N. 80° E. Dip is not constant. Some of it is fine-grained and flinty and resembles the Knife lake rock. 433. Farther up on the east side of the creek the same rock is coarser and not so siliceous, but contains chlorite or sericite. No. 434.

It was because of reports of red jasper being found here that a visit was made to this creek. This jasper was found to be in beds of Animike lying horizontally on the opposite side of the bed of the creek from the Keewatin. The bed of this stream lies in the line of contact between these two formations. The Animike is flinty and becomes more reddish farther up the creek, 435.

About one-quarter of a mile up the stream the creek spreads out into a marshy lake. A north and south Canadian survey line between 297 T and 298 T crosses the creek at the head of the rapid water. At this place, on the east side of the stream, are thick beds of horizontal Animike. It has here the nature of a somewhat decomposed, fine, dark conglomerate. The pebbles in it are iron rusted; they are sometimes an inch long, but generally less than half an inch. They are flattened horizontally, 436. On a knoll above this conglomerate, a short distance east of it is found another outcrop of schistose Keewatin. It is greenish and somewhat sericitic, 437.

In the bed of this same creek there is found the contact between Keewatin and Animike. The two rocks are very similar in appearance and texture at the point of contact, and it is only by following up what is plainly Keewatin on one side and what is known to be Animike on the other until they come together that the junction could be determined. Even then the actual line of contact could not be seen, being in the bed of the creek of running water; but a person can stand with one foot on rock that is plainly horizontally stratified and is magnetitic, and the other foot on a slightly different rock that is lighter colored, contains no magnetite and has vertical bands of sedimentation. The space between is occupied by rock that may belong to one formation or to the other and is somewhat broken up. The best place to observe this contact is at the water's edge on the east side of the brook. The Keewatin strikes N. 80° E. and has a high dip to the north or is vertical; a little farther down the creek, however, it dips S. 75°. A ridge of the Keewatin on the east side of the stream rises above the Animike which lies unconformably in almost flat beds upon and against it. The Animike is 438. Specimens of the Keewatin are 439.

Going south from Gunflint lake to Loon lake a ridge of gabbro 300 feet high is crossed. Loon lake is 195 feet above Gunflint by aneroid. Mayhew lake is 110 feet above Loon lake. It is surrounded on the west side by low gabbro hills. This gabbro contains considerable magnetite. Several claim cabins are located on this gabbro ore. The gabbro in Tucker lake just west of Mayhew lake is also magnetitic. It is quite coarse and decayed and presents a gneissic or foliated appearance. A sample from N. E. ¼, N. W. ¼ sec. 2, 64–3 is 440. In the S. W. ¼, N. W. ¼ same section there is some fine dioritic looking gabbro which also contains magnetite. 441. This lake being 305 feet above Gunflint it is not likely that there is any Animike exposed on its shores; and indeed none was seen.

In the S. E. ¼, N. W. ¼ sec. 2, 64–3 the gabbro contains parallel bands of magnetite which dip S. 40° and give the rock a decidedly stratified aspect. Some of the beds or bands of magnetite are four or five inches thick, others only a fraction of an inch. No. 442.

The gabbro on the south side of Tucker lake presents a basaltic structure. It is very coarse and the planes of intersection are nearly at right angles with each other. One set dips S. 20° W. 45°; the other set is vertical. The gabbro here is unusually biotitic. It also contains white feldspar equal in amount to the labradorite in places. No considerable amount of magnetite was seen around the lake. It was all mixed in with the gabbro.

The point that runs through sec. 35, 65–3, on Loon lake, is highest in the N. W. ¼ sec. 35. It is made up of hills of Animike capped by trap or fine gabbro. There is here a thickness of about 150 feet of black Animike slate dipping S. 30° or more, and 30 feet or more of trap rock on top. The slate and trap are represented by 443 and 444 respectively. There is a gradual transition between these two rocks, the slates having been somewhat metamorphosed. Large pieces of coarse porphyry are seen on top of this hill. One large mass had trap rock stuck fast to one side of it. This rock was not seen in place here, but evidently belongs in the vicinity. Nos. 445 and 445 A. are the porphyry and trap. The Animike here appears remarkably thick and the gabbro on top of less depth than supposed.

In the N. W. ¼, N. W. ¼ sec. 23, 65–4 is a pit 12 feet deep which goes down through highly magnetitic beds of Animike for nine feet and then into the granite. This is nearly as high as the top of the Giant's range. The Animike is fine-grained and contains less olivine than that south of Birch lake, but has very much the same general appearance and lies like it, in strata dipping S. 15° to 30°. The best ore here is quite pure. About four feet thickness of this good ore is seen at the top of the shaft. 446. This ore possesses very strong magnetic properties. The beds of Animike which lie upon or closely above the syenite and granite seem to be very generally ferruginous and sometimes excellent ore.

The rock of the Giant's range here is very similar in texture to that south and west of Birch lake,—only it seems to contain mica here instead of hornblende. The gneissic structure, however, the color and the abundance of large bluish grains of quartz are suggestive features and remind one instantly of the Giant's range at Birch lake and at Hinsdale.

Gunflint lake to Ogishke Muncie. In the N. E. ¼ sec. 25. 65-4, just at the upper end of the first portage on the river above Gunflint lake is a bluff of Animike slates on the south side of the stream, 75 feet high. The northern face of the bluff is perpendicular, exposing finely the edges of the nearly horizontal strata of black slate. This bluff of slate is seen to lie upon trap rock into which it grades by the metamorphism of its lower beds. This trap or greenstone extends in a bare exposure for 20 rods or more north of the river. It is seen to be at least ten feet thick and has a surface dip the same as the slate beds. In some places it is porphyritic with white feldspar in spots or streaks: it then looks like the porphyry, 445, found south of Loon lake. There is a great exposure of this massive rock here, and it is plainly seen to run under the slate bluff. Some of the Animike is a breccia containing angular pieces of some sedimentary rock and of a crystalline rock as large as six inches in diameter.

The greenstone which is probably part of the Keewatin, is cut by a fine trap dyke 8 to 15 inches wide, exposed for 150 feet running N. 10° E. It contains pieces of the Animike or some other sedimentary rock. Two or three smaller dykes run at right angles to this one. Nos. 447 to 447 H are from here, also No. 448, which represents the brecciated Animike.

On the trail which runs west through sections 26, 27 and 28, 65–4, no rock other than Animike is seen. The country is elevated, 400 feet at least above Gunflint lake, and yet the nearly horizontal beds of slate are found all the way up to the top. Some of it is quite magnetic, but most of it is dark carbonaceous slate. Boulders of conglomerate apparently belonging to this formation but not seen in place are No. 449. Pebbles of quartzose and feldspathic rocks an inch and a half long are found in this conglomerate.

A diamond drill has been operated on the north side of the creek in N. W. ¼ of sec. 28, 65–4. There has also been made a cross cut here up on to the hill. The beds of Animike slate and olivinitic magnetite have here a much higher dip than usual, —S. 60°—S. 75°. There is considerable good magnetite here, but the beds are not thick enough to pay for working, 450. The tilted condition of the Animike seems to be accounted for by the rock which lies under it and which rises about 100 feet above it in the ridge north. This rock is a kind of greenstone (Keewatin), in some places looking a little like fine decomposing gabbro, containing considerable biotite at this locality. It contains labradorite and olivine and very little magnetite. The Animike is plainly seen to lie upon this rock which has slightly metamorphosed the nearest or bottom bed of quartzyte and iron ore. The lower beds of the iron bearing formation here are often exceedingly pyritous. Nos. 451 and 452 are from here. The latter number is applied to drill cores from here. These show the gradations and changes of the Animike beds as they become crystalline toward the bottom and pass through metamorphosed strata into the greenstone. The manner in which the drill penetrated the beds of Animike is shown by the following diagram.

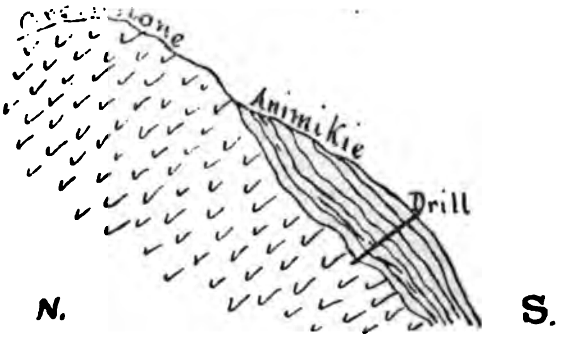

Fig. 3. Animike beds on greenstone. West of Gunflint lake. East of Chub lake.

This greenstone-gabbro ridge runs west of here for several miles, and the Animike is found to lie on it in several other localities much the same as it does here.

Another drilling was made about ½ mile south of the camp in sec. 28, 65–4. Samples from here are 453. These drill cores show the streaks and bands of hornblende crystals which are found in the lower beds of the Animike quartzyte; also the pyritiferous strata. Some of them contain biotite also and are partially metamorphosed into the underlying greenstone. This drilling according to Mr. John M. Millar of Grand Marais, one of the owners of the land, went through the ore in which it started, and about 12 feet into the "north quartzyte;" by which he must mean the underlying greenstone.

The same parties who did the work mentioned above also drilled in the N. E. ¼ sec. 29, 65–4 a short distance west of the first drillings. According to Mr. Millar the record for this working, which is near Chub lake,[*] is as follows:' Quartzyte 36 feet, clean ore 15 feet, mixed ore 17 feet, clean ore 10 feet, greenstone 12 feet. Mr. Millar calls the last "the north quartzyte," but he evidently must refer to the greenstone on which the ore and quartzyte beds lie.

From this record it seems that there is a large quantity of magnetite at this place which will probably prove to be valuable. The parties who own this property are waiting only for the advent of a railroad to commence extensive mining operations. This is the first deposit in the Animike in Minnesota known to be of sufficient extent and richness to repay investment and development.

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[*] Mr. Millar states that the name "Akeley" was applied to this lake several years before it was called "Chub lake." No map, however, has been seen to have that name and as it has already been referred to in published reports as Chub lake, the name is retained.

The usual route to Ogishke Muncie was not followed here, but the more circuitous one through the lakes southwest of Chub lake was taken. I can not refrain from stating here by way of parenthesis that the township plat of 65–4 is the most unreliable of any it has ever been my misfortune to be misled by. The lakes in the southwest part of the township are delineated by guess-work and very poor at that.

In the N. W. ¼ sec. 35, 65–5 is a knoll of Animike quartzyte. It has an elevation of about 50 feet on the south side of the stream. It dips south about 75° and strikes east and west. It contains thin beds of good magnetite, 454. Across the valley which lies on the south side of it, is found gabbro.

About a quarter of a mile west of the last is a portage of 100 paces around a rapid in the small stream. It is here seen that the knoll spoken of above is a part of a ridge of Animike that is found all along the south side of this marshy stream. On the south side of this portage trail, N. W. ¼ sec. 35, 65–5, is a precipitous bluff about 40 feet high, facing north. The lower half or perhaps one-third of this bluff consists of greenstone similar to that north of Chub lake, but containing less biotite. The upper half or two-thirds is Animike quartzyte and iron ore tilted up so as to dip S. 70° or more and striking about east and west. There is an abrupt line of contact here shown to exist between the quartzyte and the Keewatin (?) greenstone and the impression made upon an observer of the situation is that the greenstone is the cause of high dip of the quartzyte and iron ore beds.

This is a very fine contact. The stratified quartzyte is seen for several feet lying directly upon the massive greenstone. At this place then the Animike is but very slightly modified by the igneous rock beneath it, and on that account it seems as though the strata must have been deposited in a horizontal position on the greenstone and that both were folded and tilted at a later period. But at other places east of here a few miles the Animike is greatly metamorphosed so that the line of contact is not discernible, and the greenstone might be supposed to be all modified Animike. The greenstone near the contact is a little finer-grained and less massive than it is two feet below; but no other change is apparent. Specimens of the Animike from the contact are 455. The contact was seen again 150 paces west of this place; but it is not so plainly visible. Samples of the Animike from the western contact are 455 A. Specimens of the greenstone from the eastern place are Nos. 456 to 456 C, taken in order receding from the line of contact. Greenstone from the western contact is No. 456 D.

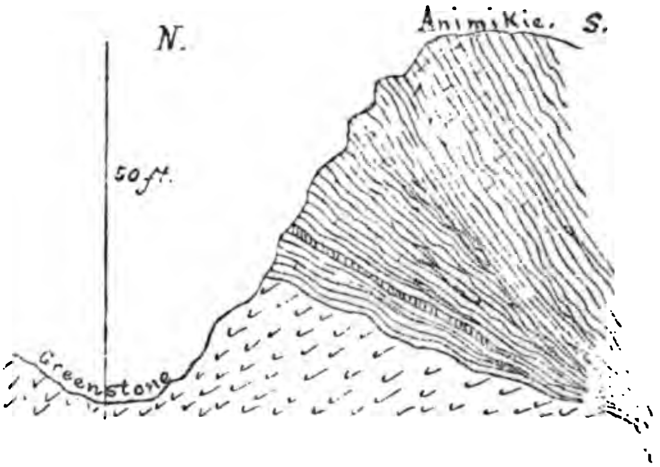

Fig. 4. Animike lying on greenstone, Township 65-5.

At the upper end of the portage are some large masses of greenstone, not in place, which are conglomeritic. Rounded pebbles and boulders of light and dark colored rock—some of them six inches in diameter—occur in it. This rock seemed to be very much like the conglomerate of Ogishke Muncie lake, 457.

On the north side of the creek from the bluff where the contact is seen there is a higher ridge than on the south side. The rock composing it does not appear to be so tough and basic as most of the rock which is subjacent to the Animike quartzyte in this region, 458. It is a fine, greenish-brown, crystalline rock containing feldspar, mica, olivine (?) and a little magnetite.

Iron ore is marked on the plat as existing in large quantities on the line between sections 12 and 13, 64-6. This locality was visited and the rock was found to be magnetitic gabbro. No good magnetite was seen. Some of the gabbro from this place is very coarse and contains coarse hornblende, 458 A.

Gabbro is the only rock found along the shore of Gabemichigama lake for some distance from the N. E. corner sec. 6, 64-5,

459. It is quite fine grained and somewhat decayed. On the south side of the island in N. W. ¼ sec. 6, 64–5, however, was found a bluff of rock rising 20 feet out of the lake, which may be modified Animike. It has gabbro on top and to the north of it. It is apparently not connected with the trap dyke which crosses the point southwest of the island on the main shore.

Iron ore being reported in the S. E. ¼ sec. 1, 64–6, this place was visited. No extensive deposits of high grade or even medium grade ore were found. The rock is gabbro which is ferruginous in spots, 461. A rock was found here, lying under the gabbro, which may be Pewabic quartzyte. It is gray and fine-granular and when decomposed resembles a sandstone. So little of it crops out of the hill here, and it is so covered by debris from above that but little could be learned concerning its relation to the gabbro, 462.

OTTER TRACK LAKE.

Red jasper and vertical magnetitic schists having been reported from this lake a visit was made to it. The lake is surrounded by high hills of siliceo-felsitic rock standing in vertical beds which strike on the average N. 65° to N. 70° E. on the south side of the lake. The strike, however, is not constant in all parts of the region bordering on the lake. In some places near the west end of the lake the evidences of aqueous deposition are unmistakable and exist in the shape of parti-colored bands running through the flinty rock. These bands do not always coincide with the schistosity which is a more general structure and subject to fewer deviations from the usual direction.

In the N. W. ¼ sec. 33, 66–6 the hills are very high, being 290 feet above the lake by aneroid. Near the lake the rock is feldspathic and graywackenitic. Farther south it becomes almost aphanitic and is flinty. One sample which shows a conglomeritic aspect of this rock is 463. A sample which is very much like the magma of the Ogishke conglomerate is 463 A. Other specimens showing the graduation into flint are Nos. 464, 464 A and 464 B.

In the bottom of the valley in N. W. ¼, N. W. ¼ sec. 33, 66–6 some of the rock is magnetitic. It stands like the rest of the rock and the ferruginous strata are very limited in extent. 465. Up on the hill east of the last are seen a couple of short twisted jaspilyte beds inclosed in the rock. They are not over a foot or eighteen inches wide and but a few feet long. They stand vertical. The iron ore in them is magnetite. No. 466. The contact between the jaspilyte and Keewatin is abrupt. 466 A.

On the north side of Otter Track lake in what would be the N. W. ¼ sec. 27, 66–6 if the U. S. survey lines were extended across into Canada, is a perpendicular bluff of rock 120 feet high and rising still much higher a short distance back from the lake. This bluff consists of sericitic or chloritic schists in vertical beds —as far as any bedding was observed—and striking N. 75° E. At the top this rock is seen to be a coarse green agglomerate like that in the Keewatin at Long lake, made up of coarse boulders of the same material as the formation in general. It is also calciferous, and the boulders are amygdaloidal, particularly around their periphery. In fact the rock is macroscopically identically the same in every respect as that around Ely. Samples of the boulders which contain amygdules are 467. Specimens from boulders which were not amygdaloidal are 467 A. The rock between and around the boulders is calciferous and sometimes quartzose, and is very frequently a breccia, 468. This rock appears very much like the regular Keewatin schists which grade into it in this region and which grade in the other direction into the fine vertically bedded siliceous rock of Knife lake, and the same rock on the north side of this lake both of which show indisputable sedimentary banding. It is impossible to separate or distinguish a line of separation between these rocks. They grade conformably into each other.

Just east of the perpendicular bluff mentioned above, the bluffs are lower. The next one east is a cliff of magnetitic jaspilyte. The beds of ore and jasper are very much crumpled and distorted; but in spite of the folding and doubling the strata are always nearly vertical. The jasper is colored various shades of red to nearly or quite black, and the iron ore does not amount to much. There is, however, a large body of these iron schists inclosed in the green schists here, the jaspilyte continuing for 100 paces along the shore and 40 paces back from the brow of the cliff. The green schist runs into and around parts of the jaspilyte in long elbows and tongues. The contact between the two was seen in several places. It was always abrupt and vertical and the change was not gradual but immediate from one to the other. The contact lines are in all directions of the compass. The jasper soon becomes narrower and stops suddenly at both ends in the line of strike. It is a little peculiar that such a crumpled mass of jasper and magnetite should occur in the green schists here and have no continuation in the line of strike nor any connection with the Keewatin. Samples of the jaspilyte are 469. The magnetite is 469 A. Specimens of schist and jaspilyte from a contact are Nos. 470 and 470 A. The strata in the jasper and iron cliff are generally less than half an inch thick but sometimes a stratum of jasper two inches wide is seen. Glaciated surfaces are observed on the side walls of these bluffs both at top and bottom.

The following figure shows how the jaspilyte beds are crumpled.

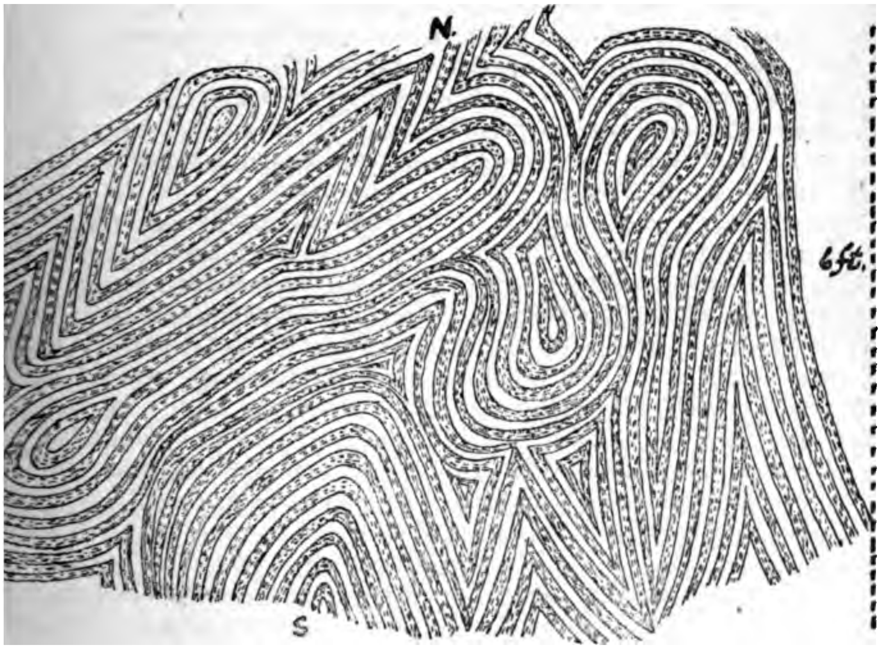

Fig. 5. Distorted beds of jaspilyte; north shore Otter Track lake.

There is a trail running north from Otter Track lake about one mile and a half from the western end. The country is surveyed and good lines are cut. The hills crossed by the trail are very high, some of them being the most elevated land in the entire region, commanding a view of the country for miles around. They are all heavily timbered and have some good white and Norway pine.

ıs and it is difficult to obtain fresh samples. No exten- ı ore deposits were seen. The beds of jasper and mag- l seem to be quite limited in extent both as to length kness, and what there is, is at least half jasper and the lf but poor iron ore.

LAKE VIRA.

ıke is reached by a portage of 900 paces from the south- . of Knife lake. It lies in sections 1, 2 and 3, 64–8 and ınded by vertical schists and argillytes. A sample of from the N. W. ¼ of S. E. ¼ sec. 2, 64–8 is a fair illus- ɔf most of the rock surrounding this lake, 476. The N. 80° E.: dip at a high angle to the north: glaciation ;. This lake does not differ much from Knife lake in ut it is 40 feet by aneroid above Ensign lake into which by a good-sized stream.

are high precipitous bluffs of schist and graywacke at end of the lake. We cut a portage of 1150 paces from 'a to Ensign lake. The country between Knife lake and e is burnt over, but that from Vira lake to Ensign lake ɔd with green timber.

N. E. ¼ sec. 10, 64–8 on Ensign lake the rock is a soft, :gillitic schist showing no bands of sedimentation but ı wavy schistose structure trending N. 80° E. The dip vertical or at a high angle to the north. Glaciation is ;.

DISAPPOINTMENT LAKE.

ake is reached by a portage of 1150 paces from Snow- :e. There are two other ways to reach it by good port- s. The physical aspect of the country around this lake different from that around Snowbank lake. It is in a gion where the bare and dead tree trunks are still stand- ıis lake is 75 feet by aneroid above Snowbank.

; 450 paces from Snowbank lake a ridge of mica schist d by the trail. The mica is in small glistening scales. ke of this schist is N. 45° E. A sample from S. W. ¼, sec. 32, 64–8 is 477.

ıica schist is cut and penetrated by intrusions or veins ;rained, red granite. This appears in the next ridge east of last, 478. Large masses of conglomeritic mica schist appear here on the surface but do not seem to be in place. This rock however is found *in situ* at the east end of the portage in S. E. ¼ sec. 32, 64–8. The schist is hornblendic and appears to be hardened. It is full of boulders of various kinds of crystalline rocks in masses of all sizes up to a foot in diameter. There is a great deal of this rock here. No. 480. A sample of mica schist from here which is not from conglomeritic beds and is more schistose than that which is, is 479. The conglomeritic mica schist is also penetrated by the red granite intrusions. 480 A. These are of all thicknesses up to 20 feet and run in all directions.

There is a dyke of trap rock on the north side of the portage at this lake. It is about 10 feet wide, and runs N. 30° W., 481. The strike of the schists here is not that of the formations generally in this region. It varies from N. E. and S. W. to N. and S. In the N. W. ¼ sec. 5, 63–8, the strike is N. 16° E.

The schist is decidedly conglomeritic in the N. E. ¼ sec. 5, 63–8. Most of the boulders are lenticular, but many of them are nearly round. The general strike, where there is any strike apparent, is N. 30° E. One sample of finely conglomeritic mica schist is 489.

In the S. ½ N. W. ¼ sec. 4, 63–8 the mica schist seems to undergo a decided change, going east along the lake shore. It becomes less schistose, contains less mica and occurs in hills and knolls of uneven hight which do not display any strike or evidence of sedimentation or schistosity. In the S. E. ¼, N. E. ¼ sec. 4, 63–8 the rock does not seem to contain any mica, but is a fine-grained, grayish-brown rock like what has been termed in some former reports of this survey "muscovado." It lies in round-topped knolls which have the shape and appearance, at a little distance, of gabbro hills. Some of it is peculiarly mottled.

Going south from Disappointment lake into the N. E. ¼ of S. W. ¼ sec. 4, 63–8 a ridge of magnetite and quartzyte is crossed. It is about ten rods wide: the strata stand nearly vertical and strike, as nearly as could be estimated, for the needle is reversed, N. 70° E. This rock is supposed to be Animike. It is oliviniticand fine-grained and the iron ore is brilliant and granular and very magnetic like the other ore from the same horizon. The only reason for doubting that it is Animike is that it stands on edge and has the "muscovado" or altered mica schist on the north of it.

Mr. H. W. Cheadle owns a claim here. He has done some strip-g which gives a good section of the rocks up the slope of the . Fine-grained gabbro is seen lying on the up-turned edges he iron ore beds. This forms a small ridge. The next ridge he south is composed of coarse gabbro containing a large per t of titaniferous (?) magnetite. South of here are high ridges this same gabbro. Nos. 490, 490 A and 490 B show the tranion from mica schist to muscovado; 491 is the Animike iron ore d quartzyte. This rock is much decayed and broken. It has fered the effects of frost and forest fires as well as of upturng, gabbro overflow and glaciation. Fine-grained gabbro from top of the ore beds is 492. Coarse gabbro is 493. There is ite a deposit of good magnetite here which may prove to be luable.

The muscovado schist or rather the mica schist has somewhat e aspect of an altered igneous rock. It is not regularly istose nor very micaceous but is full of holes and furrows, etc. e muscovado again grades into mica schist which is so feldathic as to be almost gneiss, east of here. It is also generally nglomeritic; in some places almost entirely composed of small bbles and boulders, in others not any being seen. Specimens this rock from the N. E. ¼ sec. 4, 63–8, are numbered 494.

The mica schist in the S. W. ¼ sec. 34, 64–8 approaches gneiss texture and composition. It is hardly at all schistose and in ces is almost massive but has the cleavage and color of mica ist. It contains fine hornblende crystals. Some of it is firm d brittle and may be called fine syenite, 495.

In the S. W. ¼ sec. 34, 64–8 the mica schist becomes much re regular and loses its conglomeritic aspect. It is hard and e-grained. No definite and permanent strike or dip is disrnible.

Near the west quarter post of sec. 34, 64–8 the mica schist has kind of structure which runs N. 10° W. It also becomes conmeritic, containing flattened boulders of granite and other rieties of crystalline rock eight inches long. The longer axes these boulders point N. 10° W. This is regular mica schist nglomerate not like the many boulders and fragments of diasic and porphyritic agglomerate which abound in this place.

There is a great exposure of conglomeritic mica schist in the E. ¼ sec. 33, 64–8. It all has a general strike N. 10° W., and ms to be regular mica schist, 496.

In the N. W. ¼ sec. 34 and the S. W. ¼ sec. 27, 64–8 there is a st wonderful exhibition of conglomerate and diabase. Going east from the point in the N. E. ¼ sec. 33 the conglomeritic mica schist becomes coarser and more full of boulders. These consist of various kinds of light-colored crystalline and dark hornblendic rocks; and are many of them a foot long. The mica schist gradually becomes harder and less siliceous until it is diabasic. East of the lake there are high ridges rising 75 to 150 feet above the water. These become more and more diabasic until they culminate in a high ridge of nearly massive diabase about a quarter of a mile from the lake. There is a coarse schistosity seen in this ridge in places. The strike of the rocks as shown by the schistosity, the direction of the longer axes of the boulders and the foliation of the mica schist are all *about northwest*. These ridges offer one of the finest exposures of conglomerate and agglomerate seen in this entire region. The rock in places is just as full of boulders as it can be. These become smaller and more compressed toward the east, and disappear altogether in the vicinity of the diabase ridge. Some of the diabasic schist is porphyritic. Samples of the conglomerate are 497. Diabasic schist is 498. Diabase is 499. Gneissic schist from the edge of the lake showing foliation which was northwest is 500. Biotite schist from a well-defined dyke about a foot wide which cuts the diabasic agglomerate, running about east and west, is 501.

It is quite remarkable that there is here a gradual transition from mica schist to diabase. There is no place where there is an abrupt change. The mica schist is conglomeritic and the diabase is agglomeritic. They are both schistose and have the same trend and seem to be vertical, as far as bedding is indicated by foliation and schistosity. It is a very thick conglomerate too: fully two miles across the strike. No attempt will be made to account for this transition here nor to prove whether there are two conglomerates here or not.

In the N. E. ¼, S. W. ¼ sec. 27, 64–8 the rock is very fine and even-grained, and so siliceous as to be flinty, 502. Glaciation is N. 34° E. No regular bedding or schistosity is seen here.

In the north end of the bay in the S. W. ¼, N. W. ¼ sec. 27, 64–8 the siliceous rock becomes porphyritic with small imperfect white and yellow feldspar crystals. It is indistinctly conglomeritic in places and is coarsely schistose, 503. Large masses of hydro-mica schist are seen here and indicate beds of this rock in the vicinity.

West of here the rock becomes a porphyritic conglomerate and in places over quite a wide extent is micaceous porphyritic conglomerate. Many of the included boulders are more porphyritic than the magma. The strike is N. 10° W. All of this rock is more or less hornblendic. Around the lake shores the rock is peculiarly pitted and full of holes where some of the softer boulders have been washed out. No pieces of red jasper were noticed in this conglomerate, such as are seen in the Ogishke Muncie conglomerate. Wherever the rock is decidedly micaceous it is intersected and penetrated by *red* granite or syenite intrusions. This is especially the case on the large island in the S. E. ¼ sec. 32, 64-8.

ROUND LAKE.

This body of water lies west and southwest from Disappointment lake, the waters from which flow through Round lake before reaching Snowbank lake. It is 30 feet lower than Disappointment lake, and is reached from it by a portage of 540 paces. Mica schist is seen on the trail. It is more feldspathic and compact or gneissic than that farther northeast. In the N. E. ¼ sec. 6, 63-8 the mica schist changes to gneiss or syenite gneiss. There is but a small quantity of this rock here, however, most of it being a mixture of mica and hornblende gneiss and mica schist. The beds have been considerably crumpled so that no general strike is observable. A sample of mica schist from the S. E. ¼ of N. E. ¼ sec. 6, 63-8 is numbered 482. Syenite gneiss from the N. W. ¼, N. E. ¼ sec. 6, 63-8 is 483.

The west side of Round lake has syenite around the shores. This becomes dark and siliceous and changed into a peculiar rock that seems to have been affected by the proximity of some igneous rock or other metamorphosing agent. 484.

In the N. W. ¼, N. E. ¼ sec. 7, 63-8 the syenite lies under a hill of gabbro which has a bold face on the north side nearly or quite 100 feet high. This syenite is sometimes micaceous enough to be called hornblendic gneiss. It has been somewhat broken up here and the contact between it and the gabbro is not visible. The latter rock is somewhat finer near the contact with the syenite than at the top of the hill. Syenite is represented by 485: the gabbro by 486.

In the S. E. ¼ sec. 6, 63-8 the rock is mica schist hardened by the vicinity or contact of the gabbro. The gabbro ridge runs south of the lake and really does not appear at any point on the lake shore. Samples of mica schist from the above-mentioned locality are 487. Some of it is flinty and has very little if any mica in it.

To the northeast of the last is a knoll of fine red quartzyte or syenite. It is probably part of a large intrusion in the mica schist. 488.

The mica schist in the southeast part of section six is much twisted and varies greatly in its strike and in the composition and texture of its strata. Some are hard and siliceous and others are soft and iron-stained. It is cut by numerous veins or intrusions of granite and is slightly conglomeritic in places.

TOWNSHIP 63–9.

On the portage trail from Snowbank lake to the Kawishiwi river gneiss and mica schist are seen in a few outcrops within three-quarters of a mile from Snowbank. About a mile from the lake the trail passes within ten feet of a bluff of gabbro which faces east. This is in the S. W. ¼ of S. W. ¼ sec. 11, 63–9. The rock is the regular coarse labradorite gabbro. About 200 paces south of this gabbro, on the section line between ten and eleven is found a ridge of biotite, olivine schist. This has the usual strike, N. 60° E. and dips S. 75°. It is conglomeritic in many places and bears a striking resemblance to the conglomeritic mica schist found at the southeast corner of Disappointment lake. 504.

A ridge of gabbro is again crossed 450 paces south of the N. W. corner sec. 14, 63–9. This is a high ridge with a steep bluff of the coarse light-colored gabbro on the north side. Three hundred paces farther south the rock is all "muscovado" in a great ridge. No structure or bedding of any kind is visible in it. It is simply in large hills and ridges, and is fine-grained and homogeneous in texture.

A short distance north of the "quarter-post" between sections 14 and 15 this ridge of muscovado is bounded on the south by a swamp. Along the south side of the ridge, next to the swamp, is a considerable deposit of magnetite. It is the regular coarse, dull-lustred, gabbro magnetite. The rock can not be distinguished from the gabbro nor from the muscovado either. Number 505 is the muscovado. 505 A is the magnetite.

The Kawishiwi is about 12 feet above Snowbank lake where the portage from the lake strikes it. The trail passes across and by the side of gabbro ridges for half a mile before reaching the river.

oing north on the west line of sec. 16 the gabbro disappears
ort distance north of the river. The rock next north of the
bro is the muscovado-like mica schist with the usual strike
vertical dip. It is conglomeritic a short distance farther
th and is hornblendic like that on Disappointment lake. It
s its similarity to muscovado and becomes regular mica
ist, though more or less gneissic and conglomeritic, about the
t "quarter-post" of sec. 16. Sample is 506.

At 340 paces north of the "quarter-post" mentioned above, a
mp intervening, a ridge of diabase is encountered. This
s along the north side of the swamp in a N. E.-S. W. course.
is probably part of the same diabase eruption as that east of
sappointment lake, 507. Many fragments of porphyritic con-
merate are seen lying about on the surface at this place.

This ridge keeps on rising with a gentle slope until its summit
eached at the N. W. corner of section 16. From here the
cent is gradual toward the north, but not so gradual as on the
th side. The diabase is massive for some distance from
place where it was first seen. Then it begins to show a
rse schistosity and has a coarse agglomeritic appearance as in
rock at Ely, the boulders being all of greenstone and indis-
ctly outlined on the surface. The rock is strikingly similar
the Ely rock as far as the agglomeritic appearance goes; but
not soft and chloritic like that, nor does it appear to be cal-
erous. It is simply regular diabase, 508.

At 375 paces north of the southwest corner of section nine the
base has changed from a massive rock to a fine, schistose,
base agglomerate. The direction of the very evident schis-
ity as well as of the lenticular pebbles of greenstone in it, is
16° S. This is on the northern slope of the great diabase
ge, and the rock has been examined at many places so there
o doubt as to its being part of the same diabase. The coarse
lomerate has become a fine schistose pudding-stone and is
idly changing into green chloritic schist toward the north.
aples of diabase conglomerate are No. 509.

his fine greenstone agglomerate continues to be exposed for
e distance toward the north. The direction of the schistosity
ngs around to N. W. and S. E. which is the general direc-
of it in sections 8 and 9.

ome distance south of the east "quarter post" of sec. 8 a
ge of porphyritic rock which contains grains of vitreous
rtz is encountered. It is a light colored rock and when first

seen it appears perfectly massive. It has an abrupt contact with the diabase which is also more massive at this place. The porphyry appears to run in N. W.-S. E. ridges. North of here it is seen to be mixed up in every way possible with the diabase and finally, in the N. E. ¼, N. W. ¼ sec. 8, becomes the prevailing country rock.

Toward the north still farther this porphyry becomes coarsely schistose and acquires more of the green uncrystalline elements. It also loses its decidedly porphyritic aspect as the distance from the diabase ridge increases. It is slightly conglomeritic; in one place red jasper was seen in it and in another a pebble of greenstone. Nos. 510, 510 A and 510 B show these various conditions of the porphyritic rock.

The diabase continues to abound and ridges of porphyry, or porphyrel and greenstone are strangely mixed up together. In the N. E. ¼ sec. 8 are seen large ridges of jaspilyte, consisting of red and black jasper, hematite and magnetite in crumpled vertical beds running about N. 60° E. After a long and extensive examination the state of affairs seemed to be as follows: There is a large amount of this jaspilyte here. Some of these lenticular masses of jasper and iron ore were traced continuously for half a mile or even more. These masses lie in the diabase and have an abrupt contact with it. Many pieces and masses of jaspilyte of all sizes from that of a pea to the large ridges spoken of above are seen to be enclosed in massive or only slightly schistose diabase, not in any general line of strike, but at intervals separated from each other across the strike by various distances less than a mile.

Sometimes the diabase is quite coarse and appears more like dioryte with white feldspar crystals on the surface.

In some places the porphyry approaches quite near to these jaspilyte masses; but that is not to be wondered at, inasmuch as the ridges of porphyry run all through the diabase without any definite order or direction. This jaspilyte is more hematitic toward the north and west where it is identical in appearance with that at Tower. Places were seen where the diabase is quite schistose at the contact with the jaspilyte and even as soft and greasy feeling as the soft schists in some of the Tower mines. The beds of jaspilyte are nearly as much distorted as at Tower. This diabase is seen on both sides of the iron ore and cutting across the beds. It also seems to contain fragments of the porphyry and becomes porphyritic itself in the vicinity of the porphyry ridges. Specimens of the diabase, which is found enclosing the large and small masses of jaspilyte in the N. E. ¼ sec. 8, are 511. Contact specimens with the jasper are 511 A. Samples of diabase containing small masses of jaspilyte are 511 B. Porphyritic diabase containing a piece of porphyry is 511 C. Samples of the soft sericitic or talcose rock are 512. This rock being so soft is always found in low places and could not be seen to be certainly part of the diabase. Sometimes the rock next to the jaspilyte is not green and does not look like diabase but is gray and somewhat schistose, 513. Samples of the jaspilyte are seen in 514.

The porphyry becomes more and more prevalent toward the N. E. "forty," sec. 8 until there is no more diabase nor jaspilyte. There is, however, a dyke of green trap that runs under Hugh Copeland's cabin in the N. W. ¼, N. E. ¼ sec. 8. It is about 30 inches wide and can be traced for 200 paces or more running about north and south through the porphyry. It is not perfectly straight but curves some and is faulted in two or three places. The course of it is also interrupted at one place north of the cabin by strings and branches from the porphyry mass which make it appear as if they both were plastic about the same time. Sample of the porphyry is 515. The dyke rock is 516.

The above observations are considered to be of importance as they seem to prove beyond doubt that *the jaspilyte beds are enclosed in basic rock of igneous origin.*

This region and these beds of iron ore contain some of the most promising deposits seen during the past season. There is good reason for believing that there are valuable and extensive beds of iron ore in the northern part of this township.

The ridges of diabase and porphyry alternate southeast of Copeland's cabin. A sample of rock composed of a tenacious green mineral is 517.

In some places the diabase is agglomeritic in close proximity to the enclosed masses of jaspilyte, the diabase all around such a mass containing the forms and outlines of greenstone pebbles. There is also conglomerate closely interbedded with this diabase agglomerate and apparently of a later date. It has for a magma the earlier fine agglomerate (?). These two sometimes come into direct contact, standing side by side. No. 520. This later conglomerate contains almost exclusively fragments of the porphyry and of the jaspilyte. It is never very thick and generally lies between the greenstone and the porphyry.

There are occasional tendencies toward a micaceous nature in the porphyry, and a thin stratum of schist bedded by sedimentation is seen here and there, 518.

Some of the fragments of jaspilyte seen enclosed in the greenstone are perfectly white jasper or quartzyte which crumbles into fine grains upon hammering, 519. This also is like the same fine granular quartz beds in the jaspilyte north of Tower.

In only one place was the iron ore and jasper seen in contact with the porphyry. At this place a bed of jasper three inches thick has porphyry on one side and diabase on the other. They come very close together in many places, but in all other cases observed there was a thin wall or flow of diabase between them.

A vertical bluff of greenstone 20 feet high was seen in one place with a thin coating of the light colored porphyry plastered over the entire face of the bluff. A contact specimen from here is 521.

In one place the coarser diabase which when weathered shows small white feldspar crystals on the surface, was cut by a small trap dyke. The coarser, older diabase is 522. The dyke rock is 522 A.

Going north on the line between sections nine and ten the first rock is seen quite near the river. This is fine-grained mica schist which may contain olivine, 523. This rock is conglomeritic in places and particularly in a small ridge not far north of the river. The small enclosed pebbles are compressed with their longer axes pointing N. W. – S. E., 523 A. There is next a ridge of diabasic mica schist, 523 B.

Some of the beds of mica schist are siliceous and felsitic and are iron-stained, 524. At 300 paces north of the S. W. corner sec. 10, there is quite a ridge of mica schist. It strikes N. W. and dips S. W. 70°. Samples showing lines and bands of sedimentation are 525. At 400 paces there is a contact between the beds of mica schist and diabase which latter has been more or less affected by the proximity of the schist and has a less massive appearance than usual. The mica schist too has been somewhat altered; but the change is abrupt and distinct between the mica schist on the S. W. and the greenstone on the N. E.

In this place therefore the mica schist has an abrupt contact with the greenstone and does not grade into it as it appeared to on the east side of Disappointment lake. The schist here seems to have been affected by the greenstone eruption: its strike and schistosity have been bent around nearly 90° from the usual direction. The mica schist has been hardened and rendered more like the diabase so that upon a casual inspection the two might seem to run together. Mica schist from the contact is 526. The diabase is 527. A specimen of peculiar, dark mica schist which has gray figures and lumps like drops of mud all over the surface is 526 A.

This was not the main ridge of diabase but only a subordinate branch or large dyke of it. The mica schist and greenstone seem to have had quite a struggle for supremacy in this region; first one prevailing and then the other. The genèral strike is N. W. and the dip varies from S. W. 45° to vertical. There is a ridge of coarser diabase in the N. W. ¼, S. W. ¼ sec. 10. It is quite near a contact with mica schist. 528.

In many places the mica schist is full of light gray grains of soft material which weather out and leave the surface of the rock pitted with small holes. This schist is darker and less micaceous than some of the rest, but it always conforms with the general strike and seems to be a part of the general mica schist formation. 529.

The mica schist contains thin beds of green diabasic rock which run with the other beds and are also schistose. These beds are decidedly basic and only a few inches thick, but are quite persistent and maintain their general appearance and width as far as they can be followed. 530.

Going farther north the mica schist becomes harder and more feldspathic and appears to be incipient porphyry, showing how the extensive porphyry belt north of here may be altered mica schist. 531.

Some specimens of agglomeritic diabase in which the pebbles seem to have been pasted together in a very plastic state are 532. The mica schist and incipient porphyry have also a conglomeritic structure though it is rather indistinct.

A little jaspilyte is found enclosed in the greenstone in the N. W. ¼, N. W. ¼ sec. 10. The diabase is softer and chloritic and possesses the coarse agglomeritic or concretionary (?) structure seen in it so often.*

The observations made in going north on this section line simply confirm those made on the line a mile west, and demonstrate that the coarse, chloritic, schistose agglomerate is part of this great diabase eruption and that the jasper and iron ore beds are contained in it.

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* Report of H. V. Winchell. Fifteenth annual report, p. 404.

A ridge of mica schist is again encountered just south of the quarter post between sections 3 and 4. A large exposure of this rock is found here. It is quite hard and contains a little of the diabasic rock in these beds. 533. Strike is N. 16° W.

At the N. E. corner sec. 4, the porphyry is met with, and is the same in appearance as that found in the N. E. ¼ sec. 8. The relation between the porphyry and mica schist is not evident here, but they seem to have a more or less abrupt contact. Samples of porphyry are 534. The mica schist has been becoming more argillaceous and less micaceous. Here there is a large ridge of it in which the strata are greatly crumpled and the principal strike has been changed to N. 10° E. It here seems that the porphyry is not a part of the mica schist formation, but that it was protruded into the schist beds and caused all of this disturbance. Argillitic mica schist from here is 535.

Going west from here along the north line of sec. 4 a swamp is crossed, and on the west side is found a diabase ridge. Just west of the north quarter post of sec. 4 is more porphyry in knolls and ridges which penetrate and are surrounded by the diabase. They always have an abrupt contact. This porphyry is conglomeritic, containing felsitic and siliceous boulders a foot in diameter. Samples from the S. E. ¼, N. W. ¼ sec. 4 are 536. A basaltic structure is frequently seen in the porphyry.

In the S. W. ¼, N. W. ¼ sec. 4, on the ridge which lies between two small lakes is quite an exposure of red jasper and hematite. This is seen to be in beds of various thickness up to four or five feet, which do not have a common strike. Some strata, enclosed in diabase, strike east and west; while other beds only a few rods away strike E. 30° S. The beds all stand vertical and *are very little crumpled*, 537.

The diabase has a tendency to become coarsely schistose where it lies in contact with the iron and jasper, but farther away it is very hard, tough and massive. It has also a coarse agglomeritic structure, very indistinct at this precise spot, but quite noticeable a short distance east of here, and is chloritic. Nos. 538-538 C represent these rocks.[*]

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[*] An analysis of this green rock, 538 B, made by Mr. C. F. Sidener shows, as was expected, that it is basic. The full record is as follows:

Silica, SiO_2	50.47 per cent.
Alumina, Al_2O_3	18.45 per cent.

ere is also some black jasper and magnetite at this place
ed in the greenstone in the same manner. The beds are
er and seem to contain purer ore than the hematite beds.
39.

ween the N. W. corner sec. 4 and the east quarter post sec.
cided change takes place. The diabase around the south
nd west end of the small lake on the north line of sec. 4
es a schistose structure which becomes finer and more uni-
l toward the southwest. At first it is a fine agglomeritic
se schist; then it becomes more and more siliceous until it
ty and actually resembles the Knife lake rock. From this
where the rock was found to be very siliceous, a set of
nens was procured from every outcrop south as far as the
arter post sec. 8. This siliceous schist stands in vertical
which strike N. W.-S. E., and sometimes swing around to

The rock becomes more and more flinty until at the N. E.
r sec. 8 we have the regular siliceous schist of Knife lake.
here south to the E. quarter post sec. 8, this siliceous schist
n to grade into the porphyry which was found there before.
e or two places the siliceous schist seemed to be going back
base; and ridges of diabasic schist and agglomerate were
d on this line; but they seem to be part of the intruded
se which comes into contact with this porphyry farther
Thus we have diabasic schist and even massive diabase
ing siliceous and even flinty and then porphyritic, and
coming into contact again with another part of itself far-
outh. Nos. 540-540 J show this transition.

ng east from the N. E. corner sec. 8, mica schist is met with
than a quarter of a mile. It has an abrupt contact with
yry. 541.

mica schist seen in this township is fine-grained, almost
s argillaceous, poor in mica, which is always in very small
ning scales, and generally hornblendic.

oxide of iron, Fe_2O_3	2.13 per cent.
ide of iron, FeO	7.74 per cent.
CaO	6.61 per cent.
sia, MgO	6.90 per cent.
, K_2O	.30 per cent.
a_2O	2.58 per cent.
oric acid, P_2O_5	traces.
H_2O	2.34 per cent.
	97.52 per cent.

The mica schist formation becomes hornblendic and massive in the N. W. ¼, N. E. ¼ sec. 9. Fine dark syenite from same place is 542.

On the north side of the Kawishiwi river, on the line between sections 19 and 20 the mica schist is only two rods wide. On the north side of it is the coarse diabase agglomerate.

PRAIRIE RIVER FALLS.

A visit was made at the end of the season to Pokegama falls and the region of Prairie River falls for the sake of comparison with and verification of notes made previously.

No new facts were noticed, the report of last year containing all of the points which were noted this season.

Some work is being done east of the lower falls by Minneapolis parties who are searching for iron ore; although no large body of ore has yet been encountered, the prospect is encouraging.

Specimens of magnetic ore were seen at Grand Rapids which came from the property of Mr. Kearny situated about 45 miles north of Grand Rapids in Township 61–24. It seems to belong to the Keewatin and is reported to exist in paying quantities. The locality was not visited.

Mr. Chas. F. Howe, of Duluth, has explored for iron ore in Minnesota for several seasons and is very well posted on the geology of iron ores. He reports the magnetitic quartzyte of the Huronian outcropping in Twp. 59–18. It has the usual dip of about 10° to the S. S. E. and lies near the syenite which is north of it.

The facts and observations given in scattered detail in the foregoing notes if amplified and dicussed at length with all of the careful consideration which they merit would far exceed the limits assigned to this report. But a brief allusion to some points which seem to furnish clues to the solution of a few of the unsettled problems in the geology of this region may be made here without attempting anything like a full discussion or even mention of all the theories upon which the facts before us have a bearing.

The lowest or oldest formation to which these notes make any reference is probably the syenite and gneiss ridge constituting the Giant's range. Observations on this rock were made at various points between Hinsdale, on the Duluth and Iron Range railroad, and Snowbank lake: also at a few localities in the vicinity on what is supposed to be the northeastward continuation of this range. The general characteristics of the rock of this ridge are quite persistent. The vertical foliation, the unusually large grains of bluish quartz which it contains and the general aspect of the orthoclase serve to remind an observer in the Gunflint region of the same features in the rock southwest of Birch lake. Mica, however, frequently replaces hornblende or *vice versa;* and sometimes both are present. Near the surface and for fifteen or twenty feet below, this rock has a reddish or pink color; but at a greater depth it is gray.

A coarse conglomeritic structure is noted in the syenite-gneiss of this range at Hinsdale. Lenticular masses of dark hornblendic rock are seen at all depths in the gray rock at the quarries. These masses are generally more than eight inches in length, and the direction of their longer axes is vertical or nearly so. There is sometimes a foliation or schistosity in these inclusions, and this also is vertical.

A series of vertical crystalline schists is generally found next the older crystallines in other parts of this region; but north and south of the Giant's range at Hinsdale are found exposures of the sericitic or chloritic schists of the Keewatin so close to the syenite as to make it seem improbable that any crystalline schists intervene between them here. If the high ridge is the middle of an anticlinal, as seems to be indicated by the presence of the vertical Keewatin schists on the south side of the ridge, having the same strike as those on the north, what has become of the crystalline schists which lie next above the granites and syenites? Were they so highly metamorphosed and affected by pressure to such an extent that they were incorporated into the more gneissoid rock beneath them, or were they not a widespread and universal deposit? Were there elevated portions of the sea-bottom which were not covered by the sediments from which have resulted the crystalline schists, but which were later covered by the sediments of the Keewatin age? Considering this ridge to be the back-bone of an anticinal the latter supposition seems more probable.

If this be not an anticlinal how can the presence of such an extensive range of crystalline rock in the midst of greenish, chloritic, more or less argillaceous and siliceous schists be accounted for? If the vertical foliation be evidence of some former bedding structure, the only way to explain it seems to be on the supposition that a portion of these schists themselves were metamorphosed by some unusual disturbance along the line of this range. either by the proximity of some great vent below or intense pressure at this place combined with chemical and hydrothermal forces.

The next formation is that already mentioned, the crystalline schist or Vermilion series. I wish to call attention to the fact that in Twp. 63–9 this series of rocks is found to be conglomeritic over a wide area, and has been rendered hard and porphyritic by some adjacent eruption, probably that great diabase outburst of the Keewatin age. Boulders of a large variety of rocks are seen enclosed in the mica schist around Disappointment lake. This fact alone serves to distinguish it from the diabasic agglomerates in which all of the pebbles, with hardly an exception, are of greenstone and jaspilyte.*

In connection with the crystalline schists "muscovado" should be mentioned. It seems probable that this term has been employed in the 15th and 16th reports of this survey, to designate the rotted granular condition of two or three different rocks. Dr. Alexander Winchell has applied it to a rock which he identifies with the Animike. It seems to have been used also to describe fine decayed gabbro as well as an altered condition of gneiss and the mica and hornblende schists.

As far as my observation goes it has been found quite easy to recognize decayed, rusted Animike and fine rotted gabbro such as is frequently found at the northern edge of the gabbro over flow. But in several localities, notably on the south shore of Disappointment lake, there are found large exposures of a granular, yellowish-brown rock which does not possess any distinct signs of bedding or schistosity and which yields to a blow of a hammer much as semi-hardened putty would. It contains fine scales of biotite and grains of feldspar and olivine. It lies at the north edge of the gabbro in rounded knolls which resemble gabbro hills at a little distance, and when its direct connection with the surrounding rock is obscured it can not be recognized as belonging to any of the usual formations of the region nor as being anything but "muscovado."

On the south shore of Disappointment lake there is a great deal of this rock. To the south of it are masses of olivinitic ore standing in nearly vertical beds, capped with fine, yed gabbro and having coarse labradorite gabbro on the ı of it. Fortunately the lake shore affords a nearly con- ›us exposure of this rock in both directions in the line of e. It was here traced very carefully, on two different occa- , and was found to pass by insensible gradations into mica t which became more and more micaceous and typical as listance from the gabbro increased. This mica schist is the ıeastern extension of the crystalline schists which are found ı of the Kawishiwi river in townships 63–9 and 63–10, and been followed continuously from there to this lake. The ite of the Giant's range is known to have formed the northern ɘ of the Animike ocean. This range is low and narrow at this ɜ and the Animike evidently was deposited on top of the ite and up to or perhaps upon some of the mica schist h lies to the north of the syenite. Then came the gab- eruption and overflow and with it a crumpling of the a and uptilting of the Animike beds. The gabbro also al- l the mica schist where it lay upon it, to muscovado, destroy- he schistosity and bedding and even altering the mineral tituents of the rock, heating them so that they formed new ɔinations, the iron and magnesia of the biotite combining large extent with the free quartz to make olivine, though e are some minute scales of biotite left. The same explana- of muscovado appears to answer in other places where it seen. It seems, therefore, that the term "muscovado" is er an ambiguous one but would be more appropriately ap- l to mica schist altered by gabbro than to iron-bearing mike rock.

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* In his report on the Lake of the Woods, Geol. of Can. CC., Mr. A. C. Lawson says that the agglomerates of that region grade into conglomerates along the strike of the formation. This has not been observed to be the case in Minnesota.

›nformable with the crystalline schists are the grauwackes, ritic schists, diabasic schists and siliceous schists of the watin series. The foregoing notes give numerous detailed ı which it was my good fortune to observe in localities par- larly rich in instructive geological pheuomena. These facts ɜ a decided bearing on the nature and origin of the Keewatin ıp and the iron ores and associated jaspilytes which are osed in it.

ı townships 63–9 and 64–8 immense ridges of diabase and c agglomerates were found. These form a part of the Kee- in formation. They pass conformably into the siliceous and llaceous schists of that series, and become themselves soft, ɜnish chloritic schist which retains but slight resemblance to the massive eruptive rock into which they grade and of which they are a part.

In the *American Geologist* for January, 1889, the writer gave a short resumé of the conclusions which had been reached as to the origin of these basic portions of the Keewatin. The observations which forced him to the conclusions there stated were made but a short time before; and when the article was written the fact that Mr. A. C. Lawson of the Canadian geological survey had described similar rocks in the Keewatin of the Lake of the Woods and had termed those aggregations in which the boulders are of the same material as the magma, "agglomerates" was unknown to him. Mr. Lawson also had previously offered an explanation similar to that given by the writer, of the surprising gradations observed between eruptive and fragmental rocks, viz., an alternation of "volcanic ejectamenta (both flows and tuffs) and aqueous sedimentation."

Dr. G. M. Dawson had also presented the same views and says in speaking of similar rocks in the vicinity of the Lake of the Woods, "Volcanic action would appear to offer the most reasonable explanation of their origin and distribution." *

These observations appear to parallelize our green chloritic and diabasic schists and agglomerates very closely with those of Mr. Lawson's original Keewatin. We find in them the same lenticular, basic fragments, the same "concretionary?" and associated amygdaloidal structures and the same transitions into siliceous, fragmental rocks.

It is gratifying to know that the views of these experienced geologists confirm the conclusions mentioned above. The opinion primarily held by the geologists of the Minnesota survey, with the possible exception of N. H. Winchell, and which view is still maintained by Dr. A. Winchell in the 16th Annual report, was that these rocks were of sedimentary origin and that the semi-crystalline, diabasic character was the result of intense metamorphism. The view now held is not wholly in conflict with that. It admits that portions of the Keewatin formation were purely sedimentary; but claims that the larger part of it consists of a mixture of eruptive and sedimentary materials, and is in many places extensively and wholly igneous.

In the opinion of the writer this has considerable bearing on the question of the origin of the jaspilytes embraced in the green schists of the Keewatin. They are supposed to be of some sedimentary formation which was broken up and involved in the eruptions of Keewatin age. The masses of jaspilyte are angular and have abrupt contacts with the basic schists; they are highly siliceous and are of all sizes and shapes. When the masses are large they are usually in vertical position and somewhat elongated in the direction of the schistose structure in the surrounding rock. Examples of a precisely similar disruption of a sedimentary formation and its involution in an eruptive ejection are given in the foregoing pages in referring to the masses of Huronian quartzyte and magnetite enclosed in the gabbro. In several places chalcedonic quartz similar to that in the jaspilyte of the Keewatin, was found as part of the Animike. This fact is an indication of the fragmental nature of the jaspilyte; as they cannot be separated from each other,—if one is sedimentary the other must be—and there is not much doubt that that in the Animike is.

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* Geol. and Resources, Forty-ninth Parallel, p. 52.

The most recent fragmental formation found in northeastern Minnesota is the Huronian. Many observations were made upon a quartzyte belonging to this formation which seems to lie above the Animike slates and is the rock which contains the non-titaniferous magnetite. This quartzyte has been called Animike quartzyte: but seems to lie above the Animike proper. It is perfectly conformable with the slates and sometimes grades into rock which is feldspathic and argillaceous rather than siliceous. It was observed to lie unconformably upon the rock of the Giant's range in two or three places. The most interesting contact observed was where this rock—the semi-siliceous, feldspathic Huronian—is seen to lie unconformably upon the vertical Keewatin beds. This was announced to be the case by Dr. A. Winchell in the 16th report but no actual contacts were mentioned. Considering the greenstone upon which the Animike was found to lie west of Gunflint lake as Keewatin—which it undoubtedly is—three or more fine contacts of the Animike upon the Keewatin are reported in these notes. The significance of this fact has been pointed out before.

A peculiar transition was found south of the Giant's range, in sec. 13, 60–13, where the Animike is seen to grade downward into the syenite. The character of this transition, however, does not seem to be metamorphic, but rather fragmental. There seems to have been a certain amount of the loose, crystalline material which had resulted from the decay and erosion of the syenite lying on top of the solid rock in the bed of the sea. The

Animike sediments were deposited upon and around this syenite stuff. At first the material was mainly crystalline, the sediments forming but a very small part of the whole and only filling the cracks and cavities. A few feet farther up the materials were about evenly divided, the fine detritus filling large spaces between the elevated portions of the larger pieces of syenite. As the sediments increased and grew deeper the crystalline material was completely buried and no traces of the underlying rock were left except here and there a small fragment of syenite or an orthoclase crystal which came rolling in from above and settled down on the sediments. Sometimes these crystals are quite perfect and look strangely out of place in a rock which is so plainly sedimentary and so little altered.

As a rule there is a decided difference in the texture and appearance of the Animike and Keewatin rocks; the former having a smaller proportion of feldspathic and greenish, basic material, and usually containing more quartz and some magnetite. The slates too of the Animike are darker and appear to be carbonaceous; while the slates and schists of the Keewatin are argillaceous and hydromicaceous. These differences are so general that a person who has spent a season comparing and examining these rocks can usually tell at a glance to which formation a specimen belongs. In the vicinity of the east end of Gunflint lake, however, the Animike has a marked resemblance to the Keewatin and it is difficult to distinguish them. They both have somewhat the appearance of grauwacke and are less schistose and slaty than usual. They are of a dark gray color, have a rough surface on fresh fracture and show fewer bands of sedimentation than elsewhere. The Animike, however, contains fine grains of magnetite disseminated through it with a tendency toward a banded arrangement, and the Keewatin has none.

Although the Huronian quartzyte with which is associated the non-titaniferous magnetite lies unconformably upon the syenite of the Giant's range it is believed to lie above the Animike slates and to rest conformably upon them. The rock which was deposited at the border of the ocean upon the syenite seems to have been more siliceous than those portions of the same strata which were farther from the shore. Thus the rock which lies directly upon the syenite would be a quartzyte and would pass into the less acidic rocks farther south. This condition of things is believed to have been observed in Twp. 60–13. Still there is probably an extensive quartzyte which is later than the Animike and which lies directly upon the syenite because the land was slowly becoming more submerged and the sediments kept accumulating and extending farther and farther over the range of rock which constituted the northern limit to the ocean and the strata formed in its depths. The dip of the quartzyte corresponds with that of the slates wherever seen, and although the latter were not seen at any place underlying the former, yet their relative positions and mutual relations seem to indicate that they do so.

The gabbro has been so fully discussed in previous reports of this survey that it is necessary to say but a few words concerning it. The fact that it is found to embrace large fragments of the Huronian quartzyte and slates proves it to be of later origin. It is intersected by dykes of greenstone which are of still more recent date,—perhaps of the Cupriferous age, as that is said by the State Geologist in the Tenth annual report, p. 112, to be of more recent date than the gabbro. However, the appearance of these rocks in sec. 35, 58–6 gave me the impression that the gabbro is on top of the Cupriferous and hence more recent.

A coarse basaltic structure was seen in the gabbro on the south side of Tucker lake. There was also an appearance of sedimentary structure in the gabbro in N. W. ¼ sec. 2, 64–3, caused by parallel bands of magnetite several feet in length. It shows how one may be deceived by similar banded structure in other places.

Coarse hornblende, believed to be the largest ever found in this state, was found in the gabbro in the S. E. ¼ sec. 25, 63–10. Crystals six inches long were obtained. Many seen in the same place were even larger.

LIST OF SPECIMENS COLLECTED BY H. V. WINCHELL DURING THE SUMMER OF 1888.

354. Hydrated hematite. John Mallmann's working. Sec. 29, 59–14.

354 A. Gray, feldspathic rock, to which is attached a pebble(?) of hematite. Same locality.

355. Gray rock containing magnetite. Short distance west of last.

355 A. Gray rock containing limonite. From main shaft at same place.

356. Magnetitic chrysolyte. 400 paces east of the W. ¼ post sec. 10, 60–12.

357. Syenite. S. W. ¼ sec. 8, 60–12.

358. Olivinitic magnetite. One-fourth mile south of N. W. corner sec. 17, 60–12.

359. Greenish, magnetitic, olivinitic quartzyte. S. W. ¼, S. W. ¼ sec. 17, 60–12.

360. Dark, siliceous magnetite. N. E. corner sec. 19, 60–12.

361. Slaty, carbonaceous rock. Same locality.

362. Stratified magnetite and quartzyte or siliceous schist. N. W. ¼, N. E. ¼ sec. 19, 60–12.

363. Magnetite. N. W. ¼, N. E. ¼ sec. 19, 60–12.

364. Quartz conglomerate with a green matrix. From boulders seen east of Iron lake. N. W. ¼ sec. 24, 60–13.

365. Hornblendic Animike slate. A short distance north of last locality.

366. Samples showing the transition from Animike to the syenite of the Giant's range. North end of Iron lake, S. W. ¼ sec. 13, 60–13.

367. Greenish Animike rock containing a felsitic boulder. Same locality.

368. Coarse, micaceous syenite, N. E. ¼ sec. 14, 60–13.

369. Black, magnetitic rock, S. W. side of Iron lake. N. E ¼ sec. 23, 60–13.

370. Tough, dark magnetitic rock. N. W. ¼ sec. 35, 60–13.

371. Reddish-gray quartzyte. Found in fragments on the trail in N. W. ¼ sec. 32, 60–13.

372. Samples from the bottom of the Animike where it passes into and rests upon the syenite. South of the trail. S. W. ¼, N. W. ¼ sec. 32, 60–13.

373. Black, carbonaceous slate rock containing magnetite. S. W. ¼, S. W. ¼ sec. 32, 60–13. From a shaft.

374. Grayish rock containing bands of magnetite. A little N. W. of last.

374 A. Reddish, jaspery rock. Same locality.

375. Weathered samples of magnetitic rock. S. W. ¼ sec. 31, 60–13.

376. Sample of reddish, decomposed jaspery rock from top of a shaft in N. E. ¼ sec. 11, 59–14.

376 A. Hematitic rock from bottom of the same shaft.

77. Feldspathic Keewatin schists. N. W. ¼ sec. 11, 59–14.

78. Feldspathic, gray, Keewatin schist, S. E. "forty" sec. 59-14.

79. Olivinitic, magnetitic rock. From a shaft in N. W. ¼ 14, 59–14.

80. Dark, slaty rock containing needle-shaped crystals of nblende and bands of black jasper. Sec. 22, 59–14.

81. Grayish, soft, sericitic schist, S. E. ¼ sec. 17, 59–14.

82. Gray syenite of the Giant's range, Hinsdale.

82 A. Red syenite containing decayed hornblende. Found r seams or faults in the syenite at Hinsdale.

83. Hornblende schist from included boulder-forms in the nite, Hinsdale.

84. Fine, gray granite, found cutting the syenite at Hinsdale.

85. Dark, red, decomposed syenite. Three miles north of Giant's range on the railroad.

86. Gabbro. Sec. 5, 58–14. In a railroad cut three-fourths mile north of Beaver creek.

87. Dark, silico-argillaceous rock apparently carbonaceous. E. ¼, S. W. ¼ sec. 9, 58–14. On Partridge river.

88. Reddish, hematitic, quartzose rock. From a shaft in E. ¼, S. E. ¼ sec. 11, 59–14.

89. Feldspathic Keewatin schist. Near the centre of S. ¼ sec. 11, 59–14.

89 A. Quartz from veins in last. Containing talc.

90. Dark, carbonaceous (?) rock supposed to be Keewatin. ne locality.

91. Felsitic siliceous schist. N. E. ¼ sec. 15, 59–14.

92. Magnetic, olivinitic iron ore, about 200 paces southeast n last and 40 feet higher.

93. Magnetic iron ore. N. W. ¼, N. W. ¼ sec. 14, 59–14.

94. Pinkish quartzyte. Found in angular fragments on the l in Twp. 60-13.

95. Black magnetic sand. Birch lake, S. W. ¼, S. E. ¼ sec. 32, 12.

96. Fine, muscovado-like gabbro. N. E. ¼ sec. 26, 61–12.

96 A. Specimen of a boulder (?) enclosed in last.

97. Animike or Huronian quartzyte. S. E. ¼, N. E. ¼ sec. 61–12.

97 A. Hornblendic quartzyte. Same locality as last.

97 B. Quartzyte containing unknown mineral. Same place.

97 C. Magnetitic quartzyte. Same locality.

398. Stratified quartzyte and magnetite. S. E. ¼ sec. 26, 61–12.

399. Olivinitic quartzyte. E. ½, N. W. ¼ sec. 35, 61–12.

399 A. Coarse quartzyte and magnetite. Same locality.

400. Syenite, pink and rather coarse. S. E. ¼, N. E. ¼ sec. 35, 61–12.

401. Quartzyte, containing much magnetite. Same locality.

402. Hornblendic, olivinitic magnetite rock. N. E. ¼, S. W. ¼ sec. 35, 61–12.

403. Coarse quartzyte and fine chrysolyte. S. W. "forty," sec. 35, 61–12.

404. Chrysolyte. S. W. ¼ sec. 35, 61–12.

405. Olivine bearing magnetitic quartzyte. N. ½, S. E. ¼ sec. 24, 61–12.

405 A. Hornblendic samples of last.

405 B. "Slickensides." Same locality.

406. Hard, hornblendic Animike found lying upon syenite. S. E. ¼, N. E. ¼ sec. 35, 61–12.

407. Magnetite and quartzyte in banded alternation. S. E. ¼ sec. 30, 62–10.

408. Granular olivinitic rock. Same locality.

409. Fine grained olivinitic magnetite. Same locality.

410. Titaniferous (?) magnetite. Same locality.

411. Hornblendic olivinitic quartzyte. Same locality.

412. Coarse gabbro. S. E. ¼, N. E. ¼, sec. 36, 63–10.

412 A. Coarse hornblende and labradorite. Same locality.

413. Altered Animike from fragments enclosed in the gabbro. Same locality as 412.

414. Coarse magnetite. Same place.

415. Very coarse hornblende. From the gabbro. S. E. ¼, S. E. ¼ sec. 25, 63–10.

416 and 416 A to 416 E represent a transition from sericitic schist to granite.

417. Micaceous hornblendic schist. Same locality.

418. Biotitic hornblendic schist. N. W. forty sec. 4, 63–12.

419. Calciferous sericite schist. N. W ¼ sec. 4, 62–12.

420. Gabbro from lake Isabelle. N. W. ¼, S. E. ¼ sec. 35, 62–8.

420 A. Gray, fine granular rock contained in last.

421. Pebbles from a point just east of last.

422. Dyke rock. S. W. ¼, S. E. ¼ sec. 36, 62–8.

423. Fine, brown gabbro containing biotite. East of lake

Isabelle in T. 62–7.

424. Gray labradorite rock. Two miles up Swamp-lake river from lake Isabelle.

424 A. Gray gabbro with a streak of red in it. Same place.

424 B. Red gabbro. Same locality as last two.

425.
425 A. Specimens illustrating a change from gabbro to dark,
425 B. tough hornblendic rock.
425 C.

426. Hornblendic gabbro. East of the north end of lake Harriet.

427. Gabbro. From a small island near the south end of Nine Mile lake.

428. Gabbro. From west side of Crooked lake.

429. Trap rock. Sec. 15, 59–6. West of the narrows.

430. Fine grained, olivinitic gabbro. West side of Nine Mile lake.

431. Gabbro. Sec. 35, 58–6.

432. Red, impure felsyte. East of last a few rods.

433. Siliceous Keewatin schist. About 40 rods up the creek which enters the east end of Gunflint lake from the northeast.

434. Sericitic schist. Farther up the creek on east side.

435. Reddish, jaspery Animike rock. Bed of same creek.

436. Dark, ferruginous conglomerate. About one-fourth mile up the creek.

437. Greenish, sericitic schist. East of last a few rods.

438. Animike from near a contact with Keewatin. Bed of same creek.

439. Keewatin rock from same place.

440. Magnetitic gabbro. N. E. ¼, N. W. ¼ sec. 2, 64–3.

441. Dioritic. magnetitic gabbro. S. W. ¼, N. W. ¼ sec. 2, 64–3.

442. Titaniferous magnetite. S. E. ¼, N. W. ¼ sec. 2, 64–3.

443. Black carbonaceous slate. N. W. ¼ sec. 35, 65–3.

444. Greenstone. Found lying on top of 443 (H).

445. Porphyry or porphyrel. Loose mass at same place.

445 A. Trap found stuck fast to 445.

446. Very strongly magnetic iron ore. N. W. ¼, N. W. ¼ sec. 23, 65–4.

447 and 447 A to 447 E illustrate a transition from Black Animike slate to greenstone. N. E. ¼ sec. 25, 65–4.

447 F. Porphyritic trap rock. Same locality.

447 G. Dyke rock. Same locality.

448. Brecciated Animike slate. Same locality.

449. Quartz conglomerate not seen in place. From sec. 28, 65–4.

450. Magnetite. N. W. ¼ sec. 28, 65–4.

451. Biotitic altered greenstone. Same locality.

452. Diamond drill cores. Same locality.

452 A. Pyritous quartzyte from bottom of Animike at same place.

453. Drillings from about one-eighth mile south of the "camp" in sec. 28, in 65–4.

454. Quartzyte and magnetite. N. W. ¼ sec. 35, 65–5.

455. Animike from next to a contact with underlying greenstone. N. W. ¼ sec. 35, 65–5.

455 A. Animike rock from a similar contact 150 paces west of last.

456 and 456 A to 456 C are samples of the greenstone from the eastern contact taken in order receding from the line of contact.

456 D is a sample of greenstone from the western contact.

457. Conglomerate greenstone. 250 paces east of last.

458. Fine, crystalline, grayish-brown rock composed of plagioclase, mica, olivine and magnetite. North of last in a high ridge.

458. A. Coarse, hornblendic gabbro. S. line sec. 12, 64–6.

459. Gabbro. Gabemichigama lake. N. E. ¼ sec. 6, 64–5.

460. Modified Animike. South side of the island in N. W. ¼ sec. 6, 64–5.

461. Magnetitic gabbro. S. E. ¼ sec. 1, 64–6.

462. Decomposed gray quartzyte. Under the gabbro at same locality.

463. Conglomeritic grauwacke. N. W. ¼ sec. 33, 66–6. South of Otter Track lake.

463 A. Rock resembling magma of Ogishke conglomerate. Same locality.

464, 464 A and 464 B illustrate the passage of grauwacke into flint.

465. Magnetitic siliceous schist. N.W. ¼,N. W. ¼ sec. 33, 66–6.

466. Magnetitic jaspery rock. On hill east of last.

466 A. Contact specimen between 466 and siliceous greenish Keewatin schist. Same locality.

467. Amygdaloidal calciferous rock from boulders enclosed in

chloritic schist. North side of Otter Track lake. N. W. ¼ 7, 66–6, as in Minn.

. A. From similar boulders not amygdaloidal. Same

. Calciferous breccia found immediately surrounding the er forms.

. Jaspilyte. Short distance east of last.

. A. Magnetite. Same locality.

. Green schist from near a contact with 469.

. A. Jasper from same contact.

Feldspathic, semi-crystalline schist. From the corner ed "R 333" and "R 337" about half a mile north of Otter : lake.

. Coarsely porphyritic green rock. North side of a lake lies on the north side of Otter Track lake.

and 473 A. Keewatin rock turning into red and black jas- North of Otter Track lake.

B. Magnetite in green schist. Same locality.

Jasper and magnetite. Same locality.

Average sample of the non-schistose Keewatin from of Otter Track lake.

Argillyte. N. W. ¼, S. E. ¼ sec. 2, 64–8. Lake Vira.

Fine mica schist. S. W. ¼, S. W. ¼ sec. 32, 64–8. en Snowbank and Disappointment lakes.

Red, fine syenite. Cutting last.

Mica schist. S. E. ¼ Sec. 32, 64–8.

Conglomeritic mica schist. Same locality.

A. Red granite from intrusions in 480.

Trap rock from a dyke cutting 480.

Mica schist. S. E. ¼, N. E. ¼ sec. 6, 63–8. Round lake.

Syenite gneiss. N. W. ¼, N. E. ¼ sec. 6, 63–8. Round

Dark siliceous syenite. West side of Round lake.

Micaceous syenite. N. W. ¼, N. E. ¼ sec. 7, 63–8. l lake.

Gabbro. Found lying on 485.

Hardened mica schist. S. E. ¼ sec. 6, 63–8.

Fine red syenite. Intrusion in last.

Finely conglomeritic mica schist. N. E. ¼ sec. 5, 63–8. pointment lake.

490 A and 490 B represent a transition from mica schist scovado. N. E. ¼, S. W. ¼ sec. 4, 63–8.

490 C. Mottled muscovado. Same locality.

491. Olivinitic magnetite and quartzyte. Same place.

492. Fine gabbro found lying upon 491.

493. Coarse labradorite gabbro. South of last.

493 A. Titaniferous (?) magnetite. Found in last.

494. Feldspathic, muscovado-like mica schist. N. E. ¼ sec. 4, 63–8.

495. Fine, micaceous syenite. S. W. ¼ sec. 34, 64–8.

496. Conglomeritic mica schist. N. E. ¼ sec. 33, 64–8.

497. Diabasic conglomerate. From N. W. ¼ sec. 34 and S. W. ¼ sec. 27, 64–8.

498. Diabasic schist. Same locality.

499. Diabase. Same locality.

500. Gneissic schist from lake shore having a foliation from N. W. to S. E., N. W. ¼ sec. 34, 64–8.

501. Biotitic trap. S. W. ¼ sec. 27, 64–8.

502. Siliceous greenstone. N. E. ¼, S. W. ¼ sec. 27, 64–8.

503. Porphyritic mica schist conglomerate. S. W. ¼, N. W. ¼ sec. 27, 64–8.

504. Conglomeritic mica schist. S. W. ¼ sec. 11, 63–9.

505. Muscovado. North of quarter post between sections 14 and 15, 63–9.

505 A. Titaniferous (?) magnetite. Same locality.

506. Fine, gray, hornblendic mica schist. S. W. ¼, N. W. ¼ sec. 16, 63–9.

507. Diabase, 340 paces north of W. quarter post sec. 16, 63–9.

508. Diabase. N. W. corner sec. 16, 63–9.

509. Fine conglomeritic diabase. 375 paces north of the S. W. corner sec. 9, 63–9.

510. Porphyrelle. N. E. ¼ sec. 8, 63–9.

510 A. Porphyrelle containing red jasper. Same locality.

510 B. Porphyrelle containing greenstone. Same locality.

511. Diabasic rock found enclosing jaspilyte. N. E. ¼ sec. 8, 63–9.

511 A. Contact specimens of diabase and jaspilyte. Same locality.

511 B. Diabase containing fragments of jaspilyte. Same locality.

511 C. Porphyritic diabase containing fragments of porphyrelle. Same locality.

512. Soft talcose rock. Same general locality.

. Gray schistose rock found in contact with jaspilyte. locality.

. Jaspilyte (jasper and magnetite). Same locality.

. Porphyrelle. N. W. ¼, N. E. ¼ sec. 8, 63–9.

. Trap rock. Cutting last.

Rotted diabase. Southwest of last some distance.

Micaceous diabasic schist. Same general locality.

White, crumbling jasper. Sec. 8, 63–9.

. Dark, ancient conglomerate in contact with the porphy-l conglomerate. Sec. 8, 63–9.

. Contact specimen. Diabase and porphyrelle. Sec. 8,

. Coarser diabase than usual, having white crystals of ar on weathered surfaces.

A. Fine diabase cutting 522.

. Fine grained olivinitic mica schist. S. W. forty sec. 10,

A. Conglomeritic mica schist. Same locality.

B. Diabasic mica schist. North of last.

. Rusty, decomposed mica schist. Same locality.

. Mica schist showing stratification. At 300 paces north S. W. corner sec. 10, 63–9.

. Mica schist from a contact between it and diabase. 100 north of last.

. Diabase from same contact.

. Diabase. N. W. ¼, S. W. ¼ sec. 10, 63–9.

. Dark, pitted mica schist. Same locality.

. Diabasic strata in mica schist. Same locality.

. Porphyritic mica schist. North of last.

. Diabase conglomerate. Same general locality.

. Mica schist, somewhat diabasic. Just south of the quar-st between secs. 3 and 4, 63–9.

. Porphyrelle. N. E. corner sec. 4, 63–9.

. Argillitic mica schist. Same locality.

. Porphyrelloid conglomerate. S. E. ¼, N. W. ¼ sec. 4,

. Jaspilyte. S. W. ¼, N. W. ¼ sec. 4, 63–9.

. Diabase from contact with Jaspilyte. Same locality as

A and 538 B are from a distance of five and ten feet re-ively from this contact.

538 C. A phase of the diabase which does not look so bas
Same place.

539. Black jasper and magnetite. Same locality.

Nos. 540 and 540 A to 540 J illustrate a transition from
diabasic schist through siliceous argillyte to porphyrelle wh
takes place between the N. W. corner sec. 4 and the E. qua
post sec. 8, 63–9.

541. Mica schist. N. W. ¼, N. W. ¼ sec. 9, 63–9.

542. Fine, dark syenite. N. W. ¼, N. E. ¼ sec. 9, 63–9.

ELEVATIONS DETERMINED BY ANEROID BAROMETER BY H WINCHELL.

	Ft. a L. Sup
Devil's Track river at the crossing of the county road north of Grand Marais	
Top of "Pine Mountain," 12 miles from the lake	
South Brulé river at the crossing of county road	
Birch lake, Twp. 65–2	
Duncan's lake	
Rose or Mud lake	
South lake	
North lake	
Gunflint lake	1
Loon lake	1
Mayhew lake	1

Lake Vira is about the same hight as Knife lake.
Ensign lake is 40 feet lower than Knife lake.
Snowbank lake is 45 feet higher than Knife lake.
Disappointment lake is 120 ft. higher than Knife lake.
Round lake is 90 feet higher than Knife lake.
Kawishiwi river is 57 feet higher than Knife lake where the portage f
Snowbank lake strikes it. N. W. ¼ sec. 15, 63–9.

CONTACTS OBSERVED.

Animike on the syenite of the Giant's range, north of B
lake; also west of Gunflint lake, N. W. ¼ sec. 23, 65–4; also
E. ½, N. E. ¼ sec. 35, 61–12.

Gabbro on Animike, N. E. ¼ sec. 26, 61–12 south of Birch la
also south side of Disappointment lake. Gabbro on syenite,
W. ¼ sec. 24, 61–12; also N. E. ¼ sec. 7, 63–8. Fine-grai
gabbro or trap on Animike slate, east end of Gunflint la
and around Loon lake. Animike on Keewatin, creek bed
east end of Gunflint lake; also N. W. ¼ sec. 35, 65–5; also N.
sec. 25, 65–4.

Trap rock on porphyrel, Loon lake; also sec. 8, 63–9. Jaspi-te and porphyrel, Twp. 63–9, many places. Jaspilyte and dia-se, many places in Twp. 63–9. Mica schist and diabase, S. W. sec. 10, 63–9. Mica schist and porphyrel, N. E. corner sec. 4, -9.

TRANSITIONS OBSERVED.

From Animike to syenite. North of Iron lake.

From Keewatin hydromica schist to granite. N. E. ¼ sec. 9, -12.

From black Animike slate upward to fine gabbro or trap. uth side of Loon lake.

From black Animike slate downward to trap. N. E. ¼ sec. , 65–4.

From mica schist to "muscovado" and back to mica schist. . E. ¼ sec. 4, 63–8.

From mica schist to diabase. N. W. ¼ sec. 34, 64–8.

From diabase through diabasic agglomerate to chloritic schist. wp. 63–9.

From diabasic schist through siliceous schist to porphyrel. wp. 63–9.

CONGLOMERITIC STRUCTURE OBSERVED IN

Keewatin, in schistose, porphyrelloid and diabasic portions.

Animike, in various places.

Syenite of Giant's range, at Hinsdale.

Mica schist and porphyrelloid mica schist. S. E. ¼ sec. 32, 64–8.

Gabbro, containing fragments of Animike. N. E. ¼ sec. 26, 61-12.

REPORT OF ULY. S. GRANT.

IV.

REPORT OF GEOLOGICAL OBSERVATIONS MADE IN NORTHEASTERN MINNESOTA DURING THE SUMMER OF 1888.

By Uly. S. Grant.

I. General Statement.

During the latter part of June, all of July, and the greater part of August a party was employed in collecting sets, of twenty-five specimens each, of the typical rocks of northeastern Minnesota. Besides the writer, the party consisted of Mr. A. D. Meeds, of the University, and two Indians, Charley and Nick Sucker, from Vermilion lake. The traveling was done entirely by canoe, as is usual in this region. The town of Ely, which is now the northern terminus of the Duluth and Iron Range railroad, was used as a supply point, and from here three trips were made eastward and south-eastward,— each trip taking about three weeks. Most of the country from Vermilion lake east to Gunflint lake, explored by the survey during the last two summers, was passed over, and rock samples collected from various localities designated by Prof. N. H. Winchell. The samples are of museum size — three by four inches — and bear the numbers given by Prof. Winchell in the tenth, fifteenth and sixteenth annual reports of the survey. In all forty-five sets, or over eleven hundred specimens, were collected; these, together with those collected in 1886 and 1887, form quite a complete series of typical rocks of that part of the state lying north of lake Superior. The specimens were shipped to Minneapolis and are now in the rooms of the survey,—but as yet they have not been unpacked and labeled.

While collecting the rock samples some attention was paid to the geology; thus a few additional facts were noted, and several places, not before visited by the survey, were examined. But these observations were not very extensive, as the time was limited and the main object was to collect the samples wanted. This fact, together with the inexperience of the writer in the line of geology, will perhaps account for discrepancies in the following pages. The only place where any detailed observations were made was on the north shore of Gunflint lake while trying to discover the western extension of the belt of hornblende schists (Vermilion series) which lie between the vertical earthy schists (Kewatin) on the south and the gneiss on the north.

During the latter part of August, all of September and the first half of October the writer was engaged, under the direction of Mr. H. V. Winchell, in examining reported outcrops of iron ore. While thus employed, two separate trips were made,— one from Gunflint lake south to Brulé lake, and one along the Kawishiwi river in T. 63–7 and 62–9. A few notes, concerning the general geology of the country thus passed over, are given; but it should be remembered that the main object of these trips was to examine into the richness and extent of the iron ore outcrops. Notes on a few of the lakes passed through on a trip from Kawishiwi lake south to lake Superior are also given; but a full account of this trip will be found in the report of Mr. H. V. Winchell.

Owing to the numerous heavy spring rains, all the lakes and rivers were very high,— from two to five feet higher than during the summers of 1886 and 1887; this rendered examination of rock exposures along the lake shores more difficult than formerly, as in many cases the water extended back over the rocky shores to the soil. The insect pests (black-flies and mosquitoes) were also very numerous and troublesome.

The Canadian side of the boundary lakes and rivers from Gunflint lake to Ottertrack lake, seems to have been surveyed during the last year.

The rock samples, which illustrate the following notes, are numbered from 1 up to 298, the letter G being placed on each specimen, after the number. The figures are green,—paris green and shellac dissolved in alcohol being used.

The township, section and quarter section, where each specimen was found, is given. The township (in this report) is always north and the range west of the fourth principal meridian, Minnesota.

Appended to this report will be found (1) a brief summary of observations, (2) a list, with notes, of the typical rocks of which 25 specimens were collected, (3) a table of barometric elevations and (4) a catalogue of rock samples to illustrate the writer's notes.

Magnetic bearings were taken roughly in the field; these have not been corrected either for general or local variations.

II. GEOLOGICAL NOTES.

OTTERTRACK LAKE.

This is one of the boundary lakes, and extends north-east and south-west in T. 66–6. On the north shore of the lake in N. E. ¼ of N. W. ¼ sec. 27, T. 66–6 (if the Minnesota sections were extended northward to the Canadian shore) is a cliff about forty feet high; this cliff is composed of magnetic iron slates banded with red and black; the red bands are jasper and the black ones are composed mostly of magnetite. The banding is twisted and bent in every direction, but is almost always in a vertical plane. Mr. J. F. Conniff of Duluth tells me that on the south side of the lake in the N. ½ of sec. 33 (80 rods south of the lake shore), there is an exposure of these vertical iron slates; he says they appear in the form of a "vein," from four to twelve feet wide, and strike east and west. No. 1 and No. 2 are specimens he gave me from this locality; No. 3 is from the cliff on the north shore of the lake. The first outcrop on the shore west of these slates is represented by No. 4, and the first east of them by No. 5, both of which are graywacke-like rocks. A full account of this place will be found in the report of Mr. H. V. Winchell; also see the sixteenth annual report, p. 210, for the geology of Ottertrack lake.

GUNFLINT LAKE AND VICINITY.

This lake lies on the boundary in the north part of T. 65–3, and extends eastward into T. 65–2; it also touches the eastern side of T. 65–4.

On the small island in S. E. ¼ of S. E. ¼ sec. 13, T. 65–4, were found five elongated pieces of a dark schist, which is composed principally of hornblende and feldspar, the latter weathering pinkish; these pieces are in the syenite of which the island is composed; the largest piece was five feet long and seven inches wide; the long axis of each piece extends in the same direction, — i. e. N. 85° W. (Mag.). All the pieces, except one, thin out into wedge-shaped ends. No. 6 represents the syenite, and No. 7 the schist. The largest of these pieces is shown in Fig. 1.

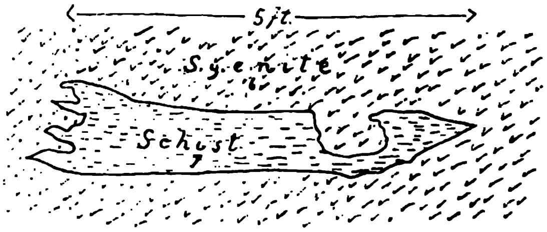

Fig. 1. Hornblende schist inclosed in syenite, Gunflint lake.

Sections north of Gunflint lake. Three sections were made north from the lake near the centre of the northern shore, the object being to discover what becomes of the hornblende schist belt (the Vermilion series of the survey) that was found north of the lake near its eastern end in 1887. If this belt continues in the same strike as there seen, it should appear again in Blackfly bay north of the narrows of the lake; but no trace of it is here found. The measurements in these sections are only roughly estimated, the ground being too rough and too much covered with underbrush to allow pacing. The location of the observations is given as accurately as possible, supposing the section lines of the Minnesota townships to be extended to the Canadian side. Fig. 2 shows the relations of this belt of crystalline schists and of the Kewatin slates to the syenitic gneiss. For the description of this belt of hornblende schists the reader is referred to the sixteenth annual report, pages 68–77, 262–6, 337, and the map on page 255.

SECTION I: North from the lake shore a little west of the line between secs. 14 and 15, T. 65–3. This would be directly north of the east end of the island in sec. 15—the only island in this part of the lake.

The first rock exposed is a vertical sericitic schist, on the lake shore; it extends east and west about 200 yards; this is the most westerly, but one, exposure of vertical schists on Gunflint lake. This rock is represented by No. 11; the exposure continues north 100 feet, and rises 8 feet above the water. After passing a swamp 250 feet wide, a hill rises 60 feet above the lake; this hill is composed of schist or slate similar to No. 11, but it is growing harder and more flinty (No. 12); this hill is 200 feet across. Beyond is another swamp about 200 feet wide, and then rises a second ridge, 400 feet in width; the first exposure is of a fine porphyrelloid rock (No. 13) with small crystals of white feldspar; these crystals are arranged more or less in layers corresponding to the strike. The rest of the hill is composed of alternating beds of black slate (No. 16) and porphyrelloid rock represented by No. 13; the latter rock varies from that in which the feldspar crystals are quite conspicuous, ⅛ inch or more in diameter (No. 14), to that in which they are quite small (No. 15). Near the top of the hill and lying in a small depression is a mass of dark trap (No. 17); the contact between the trap and slate was covered by soil. Nearer still to the top of the hill are two dikes, one and four feet in width; these dikes run parallel with the beds of slate and are exposed for over 20 feet; in the larger are fragments of baked slate; and the outer portion of this dike is very much finer-grained (No. 18) than the inner (No. 19); Nos. 18 and 19 seem to be about the same as No. 17. On the summit of the hill in the porphyrelloid schist is an elongated mass of a soft schistose rock (No. 20) running N. 70° W. (Mag.), diagonally across the bedding; this rock was traced ten feet before disappearing under the soil; the schist is in no wise changed near the contact, and near by it is bent around some smaller lenticular masses of the same rock (No. 20).

Going north for the next half mile the following country is passed over:—

Swamp;—no exposures.

Ridge, about 200 feet above the lake, composed of black slate and fine porphyrelloid schist. On the north side of this hill gabbro, similar to that on the lake shore, was found.

Rock covered.

Very hard black slate (No. 21), containing specks of iron pyrites; also porphyrelloid schist.

Rock covered.

Black slate.

Gabbro; contact with slate not seen.

Rock covered.

Gabbro represented by No. 22.

Rock covered for 50 feet.

Black slate, No. 23; strike N. 85° E. (Mag.).

Rock covered for about 150 yards, and ground rapidly descending toward the north.

At the foot of the descent was a rather coarse porphyrelloid schist (No. 24) largely composed of a soft mineral, probably sericite.

Now comes a rather level, almost swampy, place with a few small hills; it extends for about a third of a mile, as follows:—

Rock covered; swamp, about 1,000 feet.

Black slate.

Rock covered.

Micaceous schist (No. 25); this is probably in place.

Rocks covered for about 300 feet.

One hundred feet of a heavy black hornblende schist; vertical, strike N.85° E. (Mag.). At the south side of this exposure the rock is represented by No. 26; this seems to be composed of hornblende with some feldspar; the schistose structure is very pronounced. This rock soon grades into No. 27, which is heavier and has better developed hornblende crystals; the schistose structure is not very evident, except on the weathered surfaces.

The rock was now covered for about 200 feet, and then came an exposure of a very hard, dark, fine-grained mica-schist (No. 28.). This exposure was 20 feet wide (N. and S.) and 40 feet long; strike E. and W. (Mag.); vertical.

After another swamp, 400 feet wide, came an exposure, 50 feet wide, of vertical schist; this consisted of parallel bands of several kinds represented by Nos. 29, 30, 31 and 32. No. 29 is light colored, composed mostly of feldspar, which weathers pinkish, and a small amount of mica; bands of this were of all widths up to one foot; this rock made up about one-half of the exposure. No. 30 is darker and contains much hornblende. No. 31 contains still more hornblende; bands of this and the preceding were not over six inches wide. No. 32 is a very dark, fine, mica-schist; no bands of this over two and a half inches in width were seen. Samples could be found all the way between No. 29 and No. 32, but the outlines of the different bands were very distinct. The bands would often run out to needle-points and disappear.

Beyond another swamp, about 400 feet wide, was a small hill, covered by soil, but on removing the thin layer of soil the solid rock was exposed; this rock (No. 33) is composed of hornblende and feldspar; it is quite firm and on fresh surfaces appears rather massive, but on the weathered surfaces the schistose structure is plainly seen; this schistosity is vertical and strikes N. 85° E. (Mag.). The rock contained a few small areas in which the hornblende seemed to be collected in great quantity.

Beyond the last exposure was a swamp extending northward; no hills could be seen for three-fourths of a mile.

Taking the sum of the foregoing distances, roughly estimated, we have a section, straight across the strike of the slates and schists, of 6,790 feet, or somewhat over a mile and a quarter. This would give the belt of earthy schists and slates (Kewatin) a width of 4,810 feet; and the crystalline schist belt (hornblende and mica-schists), extending north from No. 26 (No. 25 not being included, as it was not positively determined to be in place), would have a width of 1,220 feet. The width of the latter belt is probably greater than 1,220 feet, as the northern limit may not have been reached and there are 670 feet between the slates and the southern outcrop of crystalline schists where no exposures were seen.

SECTION II: This section runs directly north from the lake, and is about three-fourths of a mile west of section I, or very near the line between secs. 15 and 16, if this line were extended northward from the Minnesota side. For the first half mile from the lake there is a well-cut surveyor's line.

At the lake shore there are Animike slate fragments, and just beyond this and 15 feet above the water is a ridge of gabbro, which is about 200 feet across. A swamp extends for one-half mile from the shore; beyond this swamp is about 700 feet of dry, level ground with no rock exposures. Then comes a low ridge, 50 feet across, on which are many granite boulders and a few gabbro fragments, but no rock was seen in place. After crossing 500 feet of lower ground we came to a small ridge of gneiss (No. 34) composed of quartz and feldspar, with some hornblende and a small quantity of a light yellow mineral.

After passing over two other small ridges of gneiss there comes a range of large hills of the same gneiss; from the first appearance of this rock to the range of large hills is about 600 feet. The gneissic structure can be plainly seen on the weathered surfaces; it is vertical and runs about E. and W. (Mag.). This range is from 40 to 75 feet above the swamp, and extends eastwardly,—the southern front being precipitous and running N. 55° E. (Mag.); south of it is a valley surrounded by hills; the location is shown in Fig. 2.

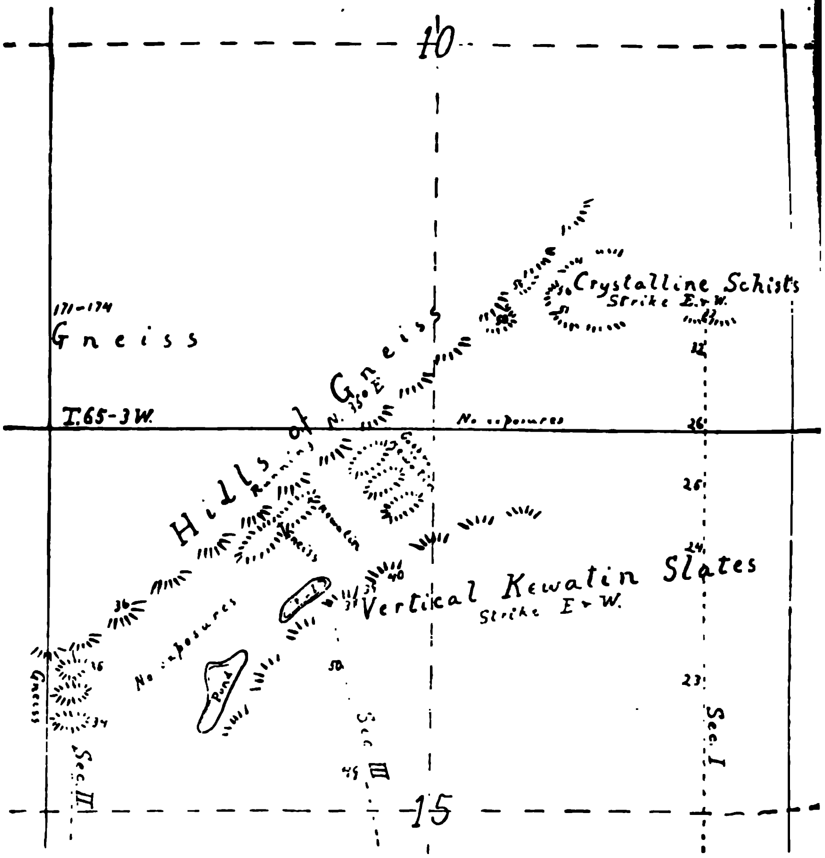

Fig. 2. Sketch showing the relation of the crystalline schists (Vermilion series) and Keewatin slates to the gneiss north of Gunflint lake.

Several pieces of micaceous schist were found in this gneiss; they were lenticular in shape and ran with the gneissic structure. The largest piece of schist was 10 feet long and 18 inches wide, and one end was irregular instead of running out to a point; No. 35 is from this piece.

A short distance east of the first observed gneiss is a trap dike, 20 feet wide, running N. 83° E. (Mag.) through the gneiss hills; this dike was traced for over 200 feet. The trap contained a few scattered crystals of feldspar, some of which are a quarter of an inch long; this rock is represented by No. 36. A mass, 3 feet in diameter, of trap quite rich in magnetite (No. 37) was found in this dike.

South of this range of gneiss hills is another range of hills nade of Kewatin slates. At the place marked 38 in Fig. 2 the lates dip northward about 80°; the strike of all the slates is E. nd W. (Mag.). Here the slate (No. 38) is interbedded with orphyrel (No. 39). About 100 feet east of this there is a dike of soft schistose rock (No. 40) running parallel with the slate and orphyrel; this dike is 4 feet wide and was traced for 25 feet; it ad split and inclosed a mass of the porphyrel (No. 42) which eems to have been changed by heat; the porphyrel at the con act has the same appearance as the inclosed mass. A part of he dike is much finer-grained than the rest, — this is shown by No. 41. This dike rock seems to have changed to a micaceous chist; the schistose structure runs with the length of the dike.

Extending from the slate hills to the gneiss range are three ow hills composed of vertical slate, on top of which is gabbro; here he slate had been somewhat bent and broken, but the general trike was E. and W. (Mag.). Just west of these are two low hills unning parallel with the gneiss range; near the eastern end of hese hills is an exposure of vertical slate, striking E. and W. Mag.); and between the two hills, and almost directly in the trike of the slate, is an exposure of gneiss. The last mentioned xposure of slate was within 100 feet of the gneiss hills. (See Fig. 2.)

Here we find a range of gneiss hills directly in the strike of the Kewatin slates; and the slate comes up to the gneiss, thus leaving no room for the belt of crystalline schists; subsequently the crystalline schists were found a short distance northeast of this place.

SECTION III: About 15° west of north, from the end of Kewatin bay (see map on page 255 of 16th An. Rep.) to the gneiss in the N. W. ¼ of sec. 15.

Forty feet from the lake is a hill, 200 feet wide, rising 40 feet above the water; the rock here is a vertical reddish-weathering schist (No. 47), striking N. 80° E. (Mag.). Six hundred feet beyond this is is another hill 300 feet wide; this is composed of vertical black flinty slate (No. 48) which weathers whitish; the strike on the south side of the hill is N. 78° E. (Mag.), and on the north side it is N. 82° E. (Mag.). After crossing a swamp we come to another hill about half a mile from the lake; here is a rather light-colored sericitic schist (No. 49) striking N. 85° E. (Mag.). About 600 feet beyond this is a large mass of gabbro (No. 50), very much decayed. And a few rods further are vertical slates striking E. and W. (Mag.). This brings us to the valley shown in Fig. 2.

Crossing over to the gneiss hills on the north of this valley and following them northeast for about 1,000 feet, we come to a large hill which is 400 feet wide (N. and S.); on the western and northwestern sides of this hill are numerous outcrops of vertical crystalline schists, striking E. and W. (Mag.). The specimens collected here are No. 51 to No. 56; these were found interbedded in the same manner as described in section I. No. 51 is a hornblende schist with a large quantity of feldspar. No. 52 has more hornblende. No. 53 is a fine dark mica-schist. Nos. 54, 55, and 56 are composed mostly of hornblende which is in quite large crystals. Directly west of this hill of crystalline schists is the gneiss range, and the outcrops on the lower ridges of this range are within 150 to 200 feet of the crystalline schists. One hundred and fifty feet W. S.-W. of 51 (Fig. 2) there is an outcrop of reddish syenite (No. 57), and 40 feet north of No. 57 the syenite is represented by No. 58; No. 57 does not show any decided gneissic structure, but this structure is very evident in No. 58; it is vertical and runs N. 85° E. (Mag.); No. 58A shows this very well. Two hundred feet from the schists and directly in the strike, the gneiss (No. 59) is again seen; the gneiss of the range of hills at this place is represented by this specimen.

The range of gneiss hills here extends northeastwardly and outcrops of gneiss can be seen for a quarter of a mile in that direction. The exact contact between the schists and gneiss could not be found.

Later in the summer, while at Gunflint lake, another trip was made to the locality described above. From the last mentioned exposure of crystalline schist I followed west over the gneiss range for nearly a mile and a half; thence south half a mile, and also north for a short distance; all the rock seen (there were many exposures) was the gneiss with the gneissic structure vertical and running nearly E. and W. At only one place was there any other rock seen; this was about three-fourths of a mile west of the schists; here the gneiss held many small pieces of dark homblendic rock represented by Nos. 170, 171, and 172. No. 170 is a dark, rather fine micaceous schist. No. 171 is coarser and shows no schistose structure. No. 172 is still coarse, have large crystals of hornblende; this rock is very similar to Nos. 27, 55, and 56. All of these specimens seem to be the same as the rock composing the crystalline schists. The pieces are mostly

ticular in shape, having the long axis east and west, but
me were angular; they are collected quite thickly in a rather
stinct area; on one side they disappear within ten inches, thus
king a rather well defined line between the patch holding the
reign pieces and the rest of the gneiss; the other side of this
tch is covered by soil, but 15 feet beyond the gneiss appears
ain. The rock in between the fragments contains no quartz
o. 173), but this rock gradually passes into the ordinary gneiss
o. 174) which contains large grains of quartz. This occur-
nce of foreign pieces in the gneiss much resembles the "con-
omeritic syenite" of Saganaga lake described by Dr. Alexan-
r Winchell in the sixteenth annual report, pages 219 and 334;
o in the *American Geologist*, vol. III, No. 3, p. 153.

The facts noted in these three sections may be summarized as
llows:

The crystalline schists show no evidences of having been twisted
d bent,—the strike is quite constant and continues so up to
ithin 200 feet of the gneiss; no outcrops were seen between this
d the gneiss, low ground intervening. The slates in one
ace near the gneiss are somewhat crumpled, but this is only
r a short distance and may have been caused by the gabbro
hich is found at that place. The crystalline schists (Vermilion
ries) and the slates (Kewatin) are cut across by a range of
enite gneiss hills which run N. 55° E. (Mag.). This syenite
ems to be the same macroscopically as that, into which the
ystalline schists pass conformably a few miles further east.
he belt of crystalline schists, if continued in their strike would
ppear again, either on Gunflint lake north of the "narrows" or
n the boundary river flowing north from the lake; but the schists
re not seen here; all the rock seen for a number of miles north
f the line between secs. 18 and 19, T. 65–3, along the lake and
iver shores (except a small area on the east side of Blackfly
ay, which is Animike) is syenite, and there is no trace of the
hists, unless, perhaps, it be a very few lenticular pieces of horn-
lende schist scattered in the syenite,—but these are found
sewhere in the syenite, far removed from any quantity of
milar rock. From the facts noted it seems that the syenite
s been pushed over or has flowed over the crystalline
hists, or that there was a fault running N. E. and S. W. and
e schist beds on the west side of this line have been pushed
uthwestwardly and now lie under the lake, or even further
uth than that. The situation of the rocks as shown by these
ctions is given in Fig. 2.

Iron location at Chub lake. This is in the N. E. ¼ of sec. 29, T. 65–4, and was visited in 1887 (see sixteenth annual report, pages 82 to 86). Since September, 1887, there seems to have been no working in the opening into the bluff on the north shore of the lake; No. 44 is a fair sample of the iron ore found at this place. A few rods west of this there is a steam engine and a large quantity of drill pipe. A diamond drill was worked here during the winter of 1887–8 by Mr. Millar of Grand Marais. The drill has gone down through the Pewabic quartzyte into the greenstone. A few pieces of the drill core (No. 45) were lying about; all of these seemed to be quartzyte, which in some places contained bands of a dark mineral, probably hornblende.

First falls north of Gunflint lake. These falls are in the boundary river in the N. E. ¼ of N. E. ¼ sec. 13, T. 65–4. The rock making the falls is the syenite gneiss (No. 62) of the region, with the gneissic structure running No. 80° E. (Mag.). On the Canadian side of the river is a diabase dike running N. 5° W. (Mag.); this is first seen at the waters edge on the upper (south) side of the falls. The dike rock is fairly represented by No. 61, but in some places it is finer grained, as shown by No. 61 A. After running north about 50 feet the dike suddenly ends,

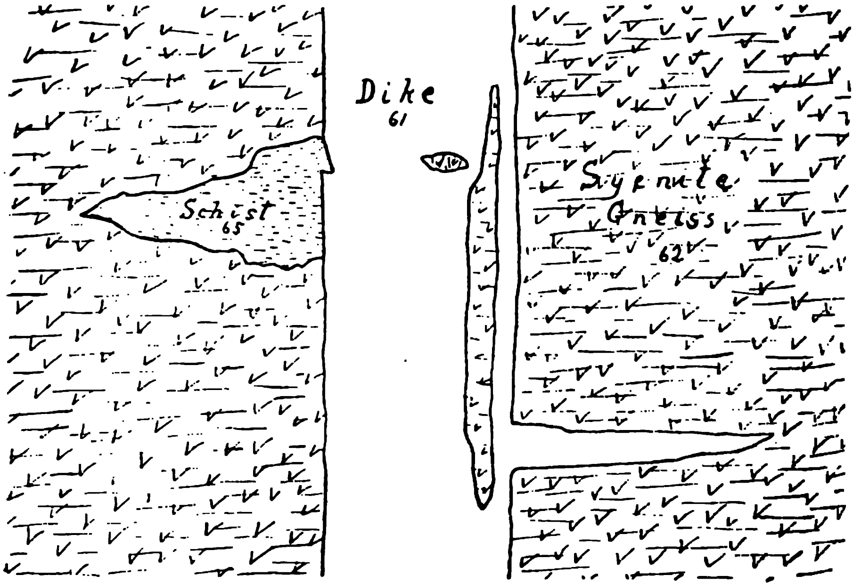

Fig. 3. Diabase dike in the syenite at the falls of the Boundary river, N. E. ¼ of N. E. ¼ sec 13, T. 65–4.

but a few feet east of this it is seen again and was traced northward for about 150 feet; here the rock contains more of a yellowish-green mineral, as is shown by No. 63; and in some places the surface is pitted (shown by No. 64) by the decay of one of the mineral constituents.

From this dike a spur, four inches wide, runs out into the syenite for four feet and ends in a point (see Fig. 3). Here is a piece of the syenite in the dike; this piece is eight feet long and four inches wide; the gneissic structure is parallel to that of the syenite through which the dike cuts. There is also a small lenticular piece of syenite in the dike, but in this the gneissic structure is at right angles to the other. A mass of hornblende schist (No. 65) is inclosed in the syenite, and one end of it is in contact with the dike, while the other end runs to a point; the schistose structure runs with the gneissic structure of the surrounding rock, but at one point (A, Fig. 3) it is slightly bent. By the firmness with which the piece of schist is connected with the syenite and by the looseness of its joint with the dike one concludes that the schist was in the syenite before the dike cut it; there is no part of the piece of schist on the other side of the dike. Several other smaller, lenticular pieces of hornblende schist, resembling the one above described and in no way connected with the dike, were found in the syenite near by.

OGISHKE-MUNCIE LAKE.

This lake lies in secs. 13, 23, 24, 26, and 27 of T. 65–6. The geology of its shores has been described in the former reports of the survey, but a few additional notes from one place are here given.

The place where these notes were taken is on the southeast shore of the lake, opposite the north end of the small island which lies just north of the narrows in sec. 24; or in the S. E. ¼ of N. E. ¼ of N. W. ¼ sec. 24. At the water's edge is a gray quartzyte (No. 76), probably the same as the gray quartzyte in the section given on page 371 of the fifteenth annual report: no bedding was seen in this quartzyte. A few feet from the shore are some vertical black slates (No. 77), striking N. 40° E. (Mag.); the contact between the slates and quartzyte was very distinct, and in one place the quartzyte extended across the strike of the slates. On the shore a few feet east of this place the quartzyte held a bed of slate about one foot wide and striking in the same direction as the other slates; on one side the slate bed by gradual change passed into the quartzyte, while on the other side the two were separated by a sharp line. These black slates contained many siliceous bands (shown in the specimens collected) which sometimes are an inch in width. No. 78 is from one of these bands; this seems to be a gritty sandstone with some calcareous matter in it; it effervesces slightly with cold hydrochloric acid. Going from the lake these bands increase in size and frequency and the black slate gradually disappears. The rock then grades through Nos. 79, 80, and 81 to No. 82 which contains some quartz grains but is chiefly made up of calcareous or dolomitic matter. The last four specimens were taken in a distance of fifteen feet; the rock all weathered with a vertical schistose structure which ran parallel to the strike of the black slate,—i. e. N. 40° E. (Mag.). Three feet beyond No. 82 the conglomerate (No. 83) occurred; the contact between the two was covered; the conglomerate seems to contain some of the dolomitic matter. The distance from the lake shore to the conglomerate was not more than thirty feet.

BIRCH LAKE.

This lake extends through the western part of T. 61–11, and the southern part of T. 61–12. During the summer of 1886 some observations were made along the Dunka river (see the fifteenth annual report, page 340), but there was not time to visit the high ridge south of the lake in secs. 7, 8, and 9, T. 60–12, and trace it eastward to the river; consequently the writer was instructed to examine this locality. The high ridge, which is made up of syenite, was visited by Mr. H. V. Winchell, and a full account of it can be found in his report. The notes here given were taken along the trail that runs south from the lake.

The mouth of Dunka river is near the centre of sec. 33, T. 61–12; the river is canoeable for about half a mile from the mouth; at the first rapids there is a trail running south. This trail crosses the river in the S. W. ¼ of sec. 10, T. 60–12; here the river flows over gabbro (No. 117) which contains some biotite. In one small area (about ten feet square) on the surface of the gabbro there are numerous, narrow dark bands; these are brought out very plainly by unequal weathering. The bands are parallel and vertical, running N. 35° W. (Mag.). Nos. 118 and 118A show these bands; the latter specimen was taken from a loose piece. About half a mile south of this place are many gabbro fragments (No. 119) which evidently came from rock in place near by. At the next crossing (S. W. ¼ of N. E. ¼ sec. 15) there are also some large gabbro fragments (No. 120). The river at this place flows through a swamp and no rock is exposed. Between the two crossings the trail is in many places covered with fallen trees and is difficult to follow.

Just west of the crossing in sec. 10 there is a low drift ridge; this runs a little south of west; it was followed one-fourth of a mile, where it turns more to the south and seems to disappear. A swamp extends westward from this hill, and about half a mile west of the crossing there is a low ridge, ten feet high and 300 feet long, running N. 20° E. This ridge is composed of a dark heavy quartzyte with bands of magnetite; the banding is quite regular and parallel and gives the rock a decidedly bedded appearance. The ridge runs with the strike of the quartzyte. The dip is S. 20° E. at an angle of about 30° (the direction of the dip is only estimated, as the needle was much disturbed). The specimens collected here are No. 115. This rock is probably the same as the olivinitic iron (No. 116) found on the trail in the N.W. ¼ of sec. 10 and mentioned on page 341 of the fifteenth annual report. What I have spoken of as a quartzyte is probably composed largely of olivine. The rock is a part of the Animike formation.

KAWISHIWI RIVER.

In T. 63–9. From the little bay in the S. W. ¼ of S. E. ¼ sec. 15, T. 63–9 there is a trail running northeast to the quarter post between secs. 14 and 15. On the shore the ordinary gabbro (No. 132) was found; it here held a few grains of magnetite. A quarter of a mile from the shore the trail crosses several small exposures of iron ore; these are surrounded by the gabbro; the ore is magnetite represented by No. 133, which was taken from the first of these ore exposures.

About sixty yards northwest of the quarter post between secs. 14 and 15 is a hill composed of a fine-grained rock (No. 134), which seems to be what the survey has called "muscovado." The east side of the hill is rather steep and here is some more of the magnetite (No. 135); this seems to lie under the muscovado, as it is exposed all along the base of the hill (about 250 feet) and just above and within ten feet of it the muscovado occurs in place. The contact between the two was not found. This outcrop of ore seems to be almost pure magnetite, but it occurs in the gabbro and very probably contains quite a large per cent of titanium, as all the gabbro ores do, and so would be comparatively worthless. The ore is exposed for about 250 feet and the exposure is ten feet high; the iron seems to extend under the hill indefinitely. The specimens collected fairly represent this ore.

After reaching the quarter post between secs. 14 and 15 the trail runs north on the section line to the northwest corner of sec. 14 and then east one mile, and then north on the line between secs. 11 and 12 to Snowbank lake. There are numerous exposures of rock, but it is all the ordinary gabbro. At one place a few small pieces of magnetite were seen in the gabbro. Iron was reported just west of the quarter post between secs. 11 and 12, but after search in this locality none was discovered.

Mr. Wm. Diarmid who has a claim in the N. ½ of S. W. ¼ sec. 3, T. 63–9, says that there is an outcrop of magnetite in the gabbro near the quarter post between secs. 13 and 14, T. 63–9; also one in the S. E. ¼ of sec. 7, T. 63–8. He also mentioned outcrops of jasper in the N. E. ¼ of sec. 8, T. 63–9 and in the N. W. ¼ of sec. 4. These localities were not visited by the writer, but Mr. H. V. Winchell examined the jasper in T. 63–9 later in the season.

South of Mishiwishiwi lake. The Indians apply this name to the lake, which the survey called Bald Eagle lake in the fifteenth annual report; the lake lies mostly in secs. 25, 26, and 36 of T 62–10. A river flows into the southeastern corner of the lake, and about a mile from the mouth of the river, or in the N. W. ¼ of sec. 5, T. 61–9, there is a stream flowing into the river from the south; this stream is canoeable for about a mile and a half. On the right bank of the stream and an eighth of a mile south of its mouth is a hill of gabbro, which appears to be the west end of a low ridge running east and west. This gabbro (No. 136) has a gneissic structure, which is vertical and runs N. 15° W. (Mag.), making the rock break more readily in this direction than in any other. In some places the gabbro lies in horizontal beds from two to four inches thick. The rock seems to be almost entirely composed of a feldspar (probably labradorite) and a mineral which is probably olivine; this, when not decayed, is of a yellowish-green color, but its hardness is below 6. A few rods further south, on the left bank of the stream is a small hill of the some gabbro showing the gneissic structure running in the same direction,—i. e. N. 15° W. (Mag.).

About a third of a mile south of the last mentioned hill is another gabbro hill on the left bank of the stream. The rock here is similar in composition to that above described, but is coarser grained and does not have the gneissic structure seen in the other; but many of the weathered surfaces have a peculiar banding, which is caused by the feldspar crystals being aggregated in certain lines that are vertical and run N. 10° W. (Mag.). No. 138 is a fair sample of the gabbro from this locality, while No. 137 shows the banding. The olivine, as it decays, loses its yellowish-green color and becomes darker (sometimes having a deep red color, like garnet) until on the weathered surface of the rock it appears as rusty spots. The decay of the olivine causes the rock to crumble and be easily shattered. From this hill a higher range, running east and west, could be seen about ten miles to the south.

A mile and a half from its mouth the stream narrows and rapids soon occur; here is a poor, not recently used, portage on the left side of the stream; beyond this portage the stream is crossed by many fallen logs, so we went no further.

About a mile and a half south of this place the low rounded hills, a form common to a gabbro country, seem to be collected into a low range that runs east and west. The country south of Mishiwishiwi lake has been burnt and is now partially covered by small poplars and birches, although many of the hills are treeless.

The small lake in sec. 32, *T.* 63–10. A small island near the southern shore of this lake is composed of a red syenitic gneiss (No. 139), the gneissic structure being very easily seen on the weathered surfaces and running N. 50° E. (Mag.). A little north of this is another island composed of about the same syenite, but this (No. 140) does not show the gneissic structure. These islands are in the N. E. ¼ of S. W. ¼ sec. 32. On the west side of the little bay, which is in the N. W. ¼ of N. W. ¼ sec. 32, the syenite is lighter colored and has large crystals of hornblende as shown by No. 141. At the portage, in the N. E. ¼ of N. E ¼ sec. 31 there is a light gray gneiss (No. 142) with the gneissic structure running N. 60° E. (Mag.); this gneiss holds pieces of a darker rock (No. 143), and seems to be mixed in with a mica schist and a hornblende schist a few feet south of the portage. On a little point, near where the line between secs. 31 and 32 crosses the southern shore of the lake, there is red syenite like No. 139. There was not time to examine the whole lake, but the shores seemed to be made up of syenite, of which No. 140 is a fair sample.

Mr. H. V. Winchell found the rock on the southern (?) shore of this lake to be a dark hornblende rock (No. 144), which grades into the ordinary syenite through No. 145 and No. 146.

LAKE ISABELLE.*

This lake lies in secs. 25, 35, and 36 of T. 62–8 and secs. 30 and 31 of T. 62–7.

On the west shore of the little bay in the S. W. ¼ of N. W. ¼ of sec. 35, the gabbro is composed principally of labradorite with a small amount of a glassy yellow mineral (probably olivine) and magnetite, which seems to cause the rusty spots near the surface of the rock; a few scales of biotite are also present; this gabbro is represented by No. 147. A few rods further north there is an irregular vein of granulyte (No. 148) in the gabbro; the vein is eight inches wide; one of the specimens collected shows both the vein rock and the gabbro; in the vein rock there are a few scattered scales of biotite.

On the west side of the larger bay, which is in the N. W. ¼ of sec. 35, there is a perpendicular cliff (5 to 15 feet high) of gabbro (No. 149) that is coarser grained and contains considerable olivine, but some of this yellow color may be due to a decayed condition of the labradorite. At the head of this bay, gabbro similar to No. 149 occurs.

On the shore in the S. W ¼ of N. E. ¼ sec. 35 there is a dark, heavy, fine-grained trap rock (No. 150) which gives a metallic ring when struck by the hammer; this grades into No. 151 which is coarser. A few rods back from the shore Nos. 152 and 153 were found in low outcrops; these seem to be but different conditions of No. 150. No. 152 contains considerable magnetite. A little further north on the shore this rock contains small patches of biotite, as shown by Nos. 154 and 155, the latter being a decayed condition of the former. These grade into No. 156 which is coarser. On the shore, a few steps north of No. 156, this rock (trap) is found in contact with the gabbro (N. ½ of N. E. ¼ sec. 35); the line of contact was not always distinct and in some places, as near as could be determined from the smooth-weathered surface, the transition from one rock to the other occupied two or three inches. No. 157 represents the trap near the contact with the gabbro.

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*Only the north shore of this lake is here described; for the description of the rest of the lake, and also of most of the country between here and lake Superior (this lake and the two following being the only ones here mentioned), consult the report of Mr. H. V. Winchell.

The rest of the north shore of the lake has many gabbro outcrops; for long distances there are smooth, flat exposures of gabbro rising but a few inches above the water and extending back for several yards from the shore. Three dikes are found cutting the gabbro. The first is in the N. E. ¼ of N. E. ¼ sec. 35; this dike is twenty inches wide and was traced for over sixty feet; it runs N. 30° W. (Mag.); the rock is a very fine diabase (No. 158); the contact with the gabbro is distinct. This dike occurs only a few rods north of the contact mentioned, about ten lines above. The second dike is in the S. W. ¼ of sec. 30, T. 62-7, is twenty feet wide, and could be traced only twenty-five feet, as the water covered it on one end and the soil on the other; the rock is diabase and is represented by No. 159, which was taken from the centre of the dike, and by No. 160, which was taken from one side (only one side of the dike was finely crystalline); No. 160 appears to be the same as No. 158; the contact is distinct. The third dike is in the W. ½ of sec. 31, T. 62-7 and is composed of a fine diabase represented by No. 161; this dike is fourteen inches wide and can be traced only a few feet.

BELLISSIMA LAKE.

This lake lies in the southeastern corner of T. 61-7. The north shore was examined by the writer. The shore is usually lined with boulders, most of which are large gabbro boulders, the others are smaller and apparently come from the drift; some of the latter are probably from Cupriferous rocks. Wherever the rock was exposed it was found to be very coarse labradorite gabbro, as shown by No. 162, which was obtained on the shore, about half a mile east of the west end of the lake. The north shore was low and there were no hills near the lake. No glacial striæ were seen.

PINE LAKE.

This lake lies in the S. W. ¼ of sec. 21 and in the N. W. ¼ of sec. 28, T. 60-6.

On the north shore, about one-fourth mile east of the portage from lake Harriet (just west of Pine lake), is a low rock outcrop at the water's edge; this outcrop is about twenty feet square. The rock is of three kinds; (1) a gray rock (No. 163) composed mainly of a gray feldspar; (2) a red rock (No. 164) made up of quartz and red feldspar; (3) a very fine dark trap (No. 165) holding crystals of red feldspar. No. 164A shows a darker and more siliceous condition of No. 164. Nos. 164 and 165 are very much mixed, each containing pieces of the other (see Nos. 164, 165, 165 A, and 165B). No. 163 is not found mixed with the others, but it contains a few small pieces of a dark siliceous rock as shown by No. 163A. No. 163B is intermediate between No. 163 and No. 164. The dark trap much resembles some of the trap of the Cupriferous; it is split by numerous parallel planes that are vertical and run N. 5° W. (Mag.); these are shown by the specimens.

A diabasic rock (No. 166) outcrops on the east shore near the southern end of the lake; it holds a few scattering crystals of feldspar which are sometimes nearly an inch long. This outcrop and the one mentioned above are the only two outcrops on the north and east shores of the lake.

Mr. H. V. Winchell reports several outcrops of fine diabase on the west shore of the lake; Nos. 167, 168, and 169 represent this; they seem to differ only in fineness, and all of them are much finer than that from the east shore.

The notes from Mayhew to Flying Cloud lake (inclusive) were taken on a trip from Gunflint lake south to Brulé lake and then north and west through townships 63–4, 64–4, 65–4, 65–5, and 65–6 to Ogishke-Muncie lake. The object of this trip was to examine reported iron ore locations, most of which were not found as reported,—there usually being no ore to be seen. The country passed over is one not usually traveled by white men and is seldom used by Indians except in winter; consequently the portages are very poor and badly cut, it oftentimes being necessary to go ahead and recut a portage before the canoe could be taken across. This fact, together with the fact that the township plats were very inaccurate, caused much unavoidable delay and waste of time. There are, however, some fair portages; those from Gaskanas lake to Brulé lake are quite good, and the portages from lake Ida Belle north to the lake in the S. W. ¼ of sec. 35, T. 65–4 are wide and well cut out, being used as winter roads by the Indians.

Several of the lakes on this trip were given names, as they have none on the township plats nor on any of the maps accessible. It must be admitted that this is rather a bad principle to follow, the right way being to give them the names by which y are known to the native Indians or, better still, to give the glish equivalents of the Indian names; but, as the Indian nes were not obtained, it was thought best to have some name which each lake could be known. The lakes thus named are light, Meed's, Stray, Sham, Lost, Georgia, Surveyor's, nd, Ida Belle, Narrow, Round, and Draper lakes.

MAYHEW LAKE.

ayhew lake is a narrow strip of water, about one-fourth of a e wide and a mile long, extending east and west through the th half of sec. 36, T. 65-3. It is 305 feet above Gunflint lake. ough, steep portage runs from Loon lake to Mayhew lake.

he ordinary labradorite gabbro (No. 175) is seen on the th shore in S. W. ¼ of S. E. ¼ sec. 36. On the end of the little nt, which is in the S. E. ¼ of S. E. ¼ sec. 36, the gabbro (No.) has changed somewhat, and on the south side of this point urrounds a large mass of iron ore. This ore (No. 177) seems e principally magnetite, with a little scattering feldspar, but, t is in the gabbro, it very probably contains a considerable ount of titanium. The exposure of ore was 30 feet wide and ended for about 300 feet along the shore, rising 15 feet above water. The contact between the ore and gabbro was found ne place; here the gabbro does not pass into the iron ore by dually acquiring more magnetite, but there is a sharp and inct line between the two.

here is a trail, on the town line, running south from the lake; trail was followed nearly three-quarters of a mile, and sev- l gabbro ridges, running east and west, were crossed; the bro is much decayed and is nearly half made up of magnetite . 178). From the town corner (T. 65-2, 65-3, 64-2, and 64-3) rail runs west along the line between townships 64 and 63. out a quarter of a mile west of the corner, and just south of line, there is a small lake; here were seen many fresh beaver wings. Gabbro was the only rock seen on this trail (it was owed no further than the small lake mentioned above).

IRON LAKE.

his lake is a narrow body of water extending through the th half of secs. 31, 32, and 33 of T. 65-2. It is the same hight Mayhew lake, and the two are connected by a narrow strip of er, 60 or more feet in width.

The point, which is crossed by the line between secs. 31 and 32, also the north shore of the lake in the south half of sec. 32, were examined in order to see the iron ore at these places. (This lake was described in the tenth annual report, page 80.) The point was crossed twice west of the section line and once east of it, but no ore was found except a seam of magnetite (containing a little feldspar) eight inches wide and twelve feet long, and a few small masses (No. 179) of the same in the gabbro. A low ridge of gabbro runs along the southern shore of this point, and in this ridge the magnetite was found. The gabbro is, in places, quite rich in magnetite; this is shown by No. 180, which was taken near the section line. Four sections of a quarter of a mile each were made north of the lake in sec. 32, but no ore was found. The rock was all gabbro, and none of it contained as much iron as No. 180. The shores of Iron lake are usually lined with gabbro.

PORTAGE LAKE.

Portage lake is mostly in the north half of sec. 4, T. 64-2, but an arm extends east for half a mile in sec. 5, and the line between T. 64 and 65 crosses the northern part of the lake, making a small portion of it in sec. 33, T. 65-2. It is 25 feet above Iron and Mayhew lakes.

In the S. E. ¼ of N. W. ¼ sec. 4, on the shore, is an exposure of a fine "muscovado" (No. 181): one of the specimens collected shows a porphyritic crystal which is probably labradorite. The relation of this rock to the gabbro could not be found at this place. On the south shore, in the N. E. ¼ of N. E. ¼ sec. 4, there is an exposure where the gabbro and "muscovado" were found together. The former held several large masses of the latter rock that looked like dikes, but they could not be traced far enough to determine that they were dikes. There was one lenticular piece of "muscovado" (15 inches long) in the gabbro, and in places the gabbro held pieces of the other rocks in which were small bits of the gabbro. The bottom of the exposure was entirely of gabbro. It could not be positively ascertained which was the older of the two rocks, but the "muscovado" seems to have broken up through the gabbro.

On the south shore, in the N. W. ¼ of N. W. ¼ sec. 3, the gabbro is in distinct beds from two to eight inches thick and dipping south about 30°. This bedded structure, dipping in the same direction and at about the same angle, was noticed l times, but at no other place were the beds as thin and as :t as here. The gabbro was seen at several other places south shore of the lake.

POPLAR LAKE.

s lake lies mostly in secs. 1 and 12 of T. 64–2 and secs. 7 of T. 64–1; a small portion is in sec. 6, T. 64–1, and a w bay extends into the S. E. ¼ of sec. 2, T. 64–2. It is 20 elow Portage lake. A portage leads from the east arm of ge lake to the extreme northwestern point of Poplar lake; ail is rather plain at the western end, but at the other end is almost no trail at all. No one seems to have been over ortage for two or three years. No portage could be found ıg to Duck lake (a small lake in the eastern part of sec. 3, -2) mentioned by N. H. Winchell in the tenth annual 't, page 79.

bbro was seen in several places on the portage from Portage On the little point in the N. W. ¼ of N. E. ¼ of N. W. ¼ 2, T. 64–2, the gabbro is finer than is usually found. At ›lace it varied from No. 182 to No. 183; the former shows a sic arrangement of the minerals, but this is not constant. he shore in the S. E. ¼ of N. E. ¼ sec. 12 the gabbro (No. has the labradorite collected together in spots, but this grades into the ordinary gabbro.

STRAIGHT LAKE.

is is a small, narrow lake, half a mile long and 100 yards , extending northwest and south east in the S. W. ¼ of sec. d the N. W. ¼ of sec. 18, T. 64–1. It is 25 feet below Popıke and is not shown on the township plat. The portage 3 from Poplar lake on the range line and runs a little east ıth; it is about one-fourth mile long. Gabbro was seen on ›ortage.

CARIBOU LAKE.

ribou lake is in sec. 18, T. 64–1 and sec. 13, T. 64–2. It is eet below Straight lake. The portage from the latter lake ıuarter of a mile long. Gabbro occurs on Caribou lake at the ıge and was also noticed in several places along the north :. There is a claim cabin in the S. W. ¼ of N. E. ¼ sec. 13, ⊢2, probably built within the last year, and from this cabin a line ran north for one-fourth mile; no rock was found except some gabbro at the north end of this line. The south and west shores and some of the islands of this lake have not been burnt, but all the country passed through since leaving Loon lake was burnt a number of years ago and is now covered with a not very dense growth of poplars and birches, usually not more than 25 feet high.

MEED'S LAKE.

Meed's lake is less than half a mile wide, and extends through the northern part of secs. 14 and 15 into secs. 13 and 16 of T. 64–2. It is 10 feet above Caribou lake. The timber along the shores is very dense, composed mostly of spruce, and extends down to the water's edge. No portage could be found from Caribou lake to this lake, so it was necessary to portage up the creek bed (S. E. ¼ of N. W. ¼ sec. 13, T. 64–2) for 100 yards, where the creek widens into a pond, and from the west end of this pond 200 yards more to Meed's lake. There is no high land to be seen from this lake except a hill, 90 feet above the water, in the N. E. ¼ of N. W. ¼ sec. 15.

On the geological map in the fifteenth annual report iron ore is marked all along the north shore of this lake, but, after careful search, none was found. The north shore of the lake was examined and no rock was seen except several outcrops of gabbro. Several trips were made north from the shore, as follows: (1) One-fourth mile north, a little west of the centre of sec. 15; a hill of gabbro (No. 185), mentioned above, was the only rock found. (2) Mr. Meeds went more than half a mile north about one-fourth mile west of the line between secs. 14 and 15; he reported several outcrops of gabbro. (3) One-half mile north from the little bay which extends into the S. W. ¼ of S. W. ¼ sec. 11; no rock found in place except a little gabbro at the shore. (4) From the east side of this little bay where the line between secs. 11 and 14 crosses the shore, northeast one-third mile, and then south to the lake shore. Several low ridges of gabbro, running east and west, were crossed. On the way south to the lake a small exposure of almost flat-lying (dipping S. 4°), bedded rock was found. This exposure was not more than six feet across; the rock is similar to some of the Animike beds of Gunflint lake and vicinity. One specimen (No. 186) was collected; this has a structure somewhat resembling öolite; pieces of this are quite common on the beaches of Gunflint lake. The rock is undoubtedly Animike, but I was unable to determine whether it was in place. Search was made for more of this rock, but none was found.

NORTH BRULÉ LAKE.

There is a portage starting from Caribou lake a little west of the line between ranges 1 and 2 and running south a quarter of a mile to the northwestern arm of North Brulé lake. North Brulé lake is a very irregular body of water lying in secs. 19, 20 and 29 of T. 64–1 and sec. 24 of T. 64–2. It is 20 feet below Caribou lake. Only that part of the northwestern arm lying in the N. E. ¼ of sec. 24, T. 64–2, was examined; here gabbro was seen in two outcrops. The shore has not been burnt and is covered mostly by spruce and cedar.

STRAY LAKE.

This lake is long and narrow; it lies in the north half of sec. 24, T. 64–2 and extends nearly half a mile into sec. 23. It is 30 feet above North Brulé lake. The portage leading from the last lake to Stray lake starts almost directly south of the one from Caribou lake. Gabbro was seen on this portage and also along the stream that flows from Stray lake to North Brulé lake.

GASKANAS LAKE.*

This lake is nearly three miles long, and not more than half a mile in width. It lies in secs. 22, 23, 24, 25, 26, and 27 of T. 64–2, and is 15 feet above Stray lake. We could find no portage leading south from Stray lake and so cut one to the pond which is in the S. W. ¼ of sec. 24. From this pond an old and poorly-cut portage leads to Gaskanas lake. Gabbro was seen at each end of the last portage, also on the east side of the little bay in the S. E. ¼ of N. W. ¼ sec. 26. This lake is a very pretty little sheet of water and is dotted with many green islands. The shores are densely wooded and along the south shore, especially in sec. 26 where there are two claim cabins, there is considerable good white pine.

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*This name is taken from Heinze Bros.' "Map of the Vermilion Iron Range." This map gives Winchell lake as Ababikaigan lake.

WINCHELL LAKE.*

Winchell lake is a long, narrow body of water, over five miles in length and less than half a mile in width, extending east and west in the southern part of T. 64–2 and running half a mile into T. 64–3. It is 30 feet above Gaskanas lake. The portage from Gaskanas lake (this starts from the bay in S. E. ¼ of N. W. ¼ sec. 26) is very good,—the first good one seen since leaving Gunflint lake. The water of Winchell lake is deep and very clear; the shores are well covered with timber which is composed mostly of spruce and birch with some scattering white pine. The Grand Marais Indians call this Mountain lake, probably because of the high ridge that extends along the south shore.

Gabbro occurs in place at the portage in the N. E. ¼ of S. W¼ sec. 26, T. 64–2, and there are outcrops of rock (apparently gabbro) all along the north shore, but only one of these was visited; here (S. E. ¼ of S. E. ¼ sec. 29) the gabbro (No. 187) is like the ordinary labradorite gabbro found further north, but is a little finer. We followed along the south shore of the lake, but no rock outcrops were seen until we came to the point which is crossed by the line between secs. 31 and 32, T. 64–2; here a high ridge, which extends all along the south shore of the lake and rises 50 to 100 feet above the water, comes to the shore and forms a precipitous cliff nearly 100 feet high. This cliff is composed of gabbro (No. 188) which differs from the ordinary gabbro in that it contains a considerable amount of a whitish feldspar mixed with the labradorite. The gabbro extends along the shore for a quarter of a mile west of this point.

In the N. W. ¼ of N. W. ¼ sec. 31, T. 64–2, the above mentioned ridge is cut by a small stream flowing from Sham lake, which is just south of Winchell lake. Just east of this stream is a bluff rising 80 feet above the water. The rock at the foot of the bluff is covered by large angular masses of rock that have fallen down from higher up. The first rock seen *in situ* is almost 20 feet above the water level; it is gabbro (No. 189) that is like the ordinary labradorite gabbro, except that it is more compact and contains a little light-colored feldspar. Twenty feet higher up the gabbro is represented by No. 190; this is similar to No. 189, but has more of the light-colored (pinkish) feldspar. This feldspar increased until, ten feet above No. 190, the rock was

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This name is taken from Reisetegger's map of Northeastern Minnesota.

argely composed of it. This rock (No. 191) has a red color and eems to be the gabbro changed by heat; this could not have een done by forest fires as none have passed over the shore. he feldspar crystals vary all the way from the dark (almost lack) labradorite through white to a decided red. This rock is bout as coarse and, with the exception of color, has the same ppearance as the ordinary gabbro. None of the specimens bove mentioned contain any quartz. Two feet above No. 191 he rock is very dark and tough, being composed mostly of a lack mineral probably hornblende, which is not always in efinite crystals; this gives the rock (Nos. 192 and 193) the ppearance of having a dark compact ground mass in which are cattered blotches of pinkish feldspar; in these feldspar blotches here are numerous small quartz grains. A little higher up ccurred a fine pinkish gray syenite (No. 194). No. 195 was aken just above this and No. 196 from the top of the bluff. The atter is coarser and is a distinct syenite. On examining the luff at another place the syenite was found at the top and the abbro near the bottom. Among the angular pieces at the foot f the bluff one (No. 197) was found which seems to be intermediate between the highest gabbro (No. 191) and the syenite; t resembles No. 191 and, like it, has labradorite (?) crystals, ut it also contains numerous quartz grains while No. 191 has one. On the north end of the portage to Sham lake the rock is a condition of the gabbro,— No. 198.

The above mentioned bluff shows an apparent transition from he gabbro at the bottom (No. 189) to the syenite at the top (No. 196), *the syenite lying on the gabbro.* The change is gradual, and rapid at only one place — between No. 191 and No. 192; here the transition occurs within two feet; the quartz in No. 192 is in such small grains that it was not noticed in the field, so the exact place where the quartz first appears was not determined; however, there is no distinct contact line between these two rocks, but the change from one to the other is quite sudden. It seems that the syenite is of igneous origin and has flowed out over the gabbro, the gabbro being changed somewhat by molten rock above it. No. 191 represents the changed state of the gabbro and No. 192 is the first, or lowest, part of the syenite; at any rate the change occurs between these two,— the distinct labradorite crystals disappearing and the quartz coming in.

SHAM LAKE.

This is a small lake, less than a mile long, on the line between sec. 31, T. 64–2 and sec. 36, T. 64–3. It is 15 feet above Winchell lake and is connected with it by a small stream which is a short distance east of the range line. The portage between the two lakes is less than one-eighth of a mile in length. Sham lake has no long arm extending west through sec. 36, as is shown on the township plat.

The rock at the south end of the portage is represented by No. 199; this is similar to No. 192 except that the hornblende is in distinct crystals and the quartz is not very plentiful. On the east side of the lake, in the S. W. ¼ of N. W. ¼ sec. 31, a fine red syenite (No. 200) occurs; it is composed of a red feldspar and hornblende, the feldspar making up about two-thirds of the rock; no quartz can be seen with a hand lens, but it probably contains some. The rock is probably the same as the fine red syenite or "red rock" found by Prof. N. H. Winchell both east and west of this place. Near the southwest corner of the lake, in S. E. ¼ of S. E. ¼ sec. 36, there is a low outcrop of a rock (No. 201), apparently part of the transition from gabbro to syenite; it resembles Nos. 192 and 193 from Winchell lake.

LOST LAKE.

From the south end of Sham lake there is a portage running S. S. W. for about a mile to Lost lake. This lake is not given on the township plat, and as near as could be determined it lies in the S. ½ of sec. 1 and the N. ½ of sec. 12, T. 63-3. It is about half a mile long (N. and S.) and a quarter of a mile wide. The shores are well wooded and have considerable good white pine. This lake is 30 feet above Sham lake.

On the portage from Sham lake the fine red syenite, same as No. 200, occurs in several places just east of the trail. On the west side of the lake, in S. E. ¼ of S. W. ¼ sec. 1, there is a high bluff of this same syenite; and many angular pieces have fallen down making a large talus; at this place the rock is represented by No. 202, which is of a brick-red color and contains even less hornblende than No. 200.

BRULÉ LAKE.

From Lost lake there is a portage of a quarter of a mile running S. S.-W. to a small lake, not shown on the township plat, he W. ½ of sec. 12, T. 63–3. This small lake is about a rter of a mile in length. From its southern end a portage of than a quarter of a mile leads to the bay of Brulé lake that ends into the S. W. ¼ of sec. 12, T. 63–3.

rulé lake is the largest lake seen since leaving Gunflint lake, n fact it is the largest lake in Minnesota south of the boundary east of range 9. It is seven miles long, the average width ng a mile, and extends through the central part of T. 63–3 a mile and a half into the western part of T. 63–2 (that por- of the lake in this township was not visited). The north west shores have not been burnt; here is some good white e. The southern shore was burnt some years ago and is now ered with a second growth of birches. There is a claim cabin the point in the N. E. ¼ of N. W. ¼ sec. 13, and from a Grand rais Indian, we learned that there were several more about the e. Brulé lake is 75 feet below Lost lake. The water is cle deep.

n the S. E. ¼ of S. W. ¼ sec. 12, at the water's edge, there is w exposure of a dark siliceous trap rock (No. 203), which ears to be perfectly homogeneous under the hand lens. This k contains a few small crystals of iron pyrites. No bedding cture could be seen but there were many small joints cutting rock; in one place these were parallel and dipped south ut 20°. A little further south along the east shore of this bay e bay in the S. W. ¼ of sec. 12) is an outcrop of a rock (No.) composed almost entirely of plagioclase feldspar crystals of sizes up to half an inch in length; these crystals seem to be bedded in a dark, finely crystalline matrix, but this is a very all part of the rock.

On the point in the S. E. ¼ of N. E. ¼ of N. W. ¼ sec. 13 the k at the water's edge is a white feldspar porphyry (No. 205); feldspar crystals run up to those an inch in length; the matrix dark and finely crystalline; it makes up about one-half of the k. No. 204 is probably a condition of this porphyry. Ten t above No. 205 and 30 feet back from the shore there is other feldspar porphyry (No. 206); this seems to be different m No. 205, as the matrix is much finer, darker and apparently re siliceous, and the feldspar crystals, instead of being white, e of a dull reddish-brown color; the matrix comprises about ree-fourths of the rock; the feldspar crystals weather white. e rock between these two porphyries is covered by soil.

A few yards south of No. 206 is a small exposure of a brick-red rock (No. 207) which is composed of a reddish, homogeneous and siliceous ground-mass, in which are small crystals of a brick-red feldspar, a dark mineral (probably hornblende) and quartz. This rock might be called a quartz porphyry and is entirely different from any of the others on this point. It is cut by many parallel planes (shown in the specimen) which are vertical and run east and west. On the north side of this exposure the red rock is in contact with a fine diabase (No. 208); the contact line is distinct but was exposed for only a few inches; where seen it was vertical and ran east and west. Near the contact the ground-mass of No. 207 becomes darker and more siliceous; this is shown by No. 207A.

Where the line between secs. 13 and 14 strikes the north shore the rock is similar to No. 204. This same rock occurs on the point in the N. W. ¼ of N. E. ¼ sec. 14 and also on the small island just south of this point. The shore was not examined again until reaching the large island in the centre of sec. 17; no outcrops were seen along the south shore of this island. On a small island in the S. E. ¼ of S. E. ¼ sec. 18 there is a dark, diabase-like rock inclined to be amygdaloidal (No. 209); this is quite finely crystalline and inclines to a dark purple color. In places in this rock there are small blotches of a reddish feldspar; the centre of each blotch is composed of a dark mineral, probably hornblende. This rock also occurs near the west end of the island that is cut by the line between secs. 17 and 18, and on the east end of the portage towards Georgia lake.

It is to be regretted that we were unable to more carefully examine the relations of the rocks from the south shore of Winchell lake, to and through Brulé lake, but our provisions would not warrant a longer stay.

LAKE GEORGIA.

This lake lies in the W. ½ of sec. 18, T. 63–3, and sec. 13, T. 63–4, and small bays run into secs. 14 and 24. It is 6 feet below Brulé lake. The shores have been burnt and are now covered with small birches and poplars. A stream flows from Brulé lake to lake Georgia and the portage between the two lakes is in the S. W. ¼ of sec. 18; it is only 200 feet, and not a quarter of a mile, as shown on the plat. Lake Georgia has no arm extending into sec. 12, T. 63–4, as is shown on the government plat.

In the north branch of the arm that extends into the S. W. ¼ f sec. 18, a short distance west of the portage from Brule lake, here is a rock (No. 210) which appears to be a condition of the abbro. A little west of this, and on the north shore of this rm, is an outcrop of a feldspar porphyry (No. 211); this seems o be somewhat similar to No. 206; the feldspar crystals are redlish, but rather scattered — probably making up not more than ne-tenth of the rock. On the north shore of the lake in the N. E. ½ of S. W. ¼ sec. 13, T. 63–4, there is a trap rock (No. 212); hich is in contact with the gabbro, here represented by No. 213; he two specimens were taken within three feet of each other; he contact line was covered by soil. No. 212A shows the trap urther from the contact; it is much coarser than No. 212. Gabro also occurs where the line between secs. 13 and 14, T. 63–4 uches the northern shore of the lake.

SURVEYOR'S LAKE.

This lake is in sec. 12, T. 63–4. It is shown on the township at as an arm of lake Georgia, but there is no connection between e two except a small stream flowing from Surveyor's lake; the rtage between these lakes is in the N. E. ¼ of sec. 13 and is er an eighth of a mile long. The aneroid shows no difference hight between the two lakes, but Surveyor's lake is a little gher than the other. North and east of this lake are hills 50 100 feet high.

In the S. W. ¼ of sec. 12 there is a deep bay running west for arly half a mile. At the end of this bay on the portage going st to Found lake is a fine red syenite (No. 214), similar to Nos. 0 and 202. There is a ridge extending along the north side of is bay; the red rock (syenite) in the ridge can be seen from e lake.

FOUND LAKE.

Found lake is in the S. ½ of sec. 11, T. 63–4. It is a small lake, ss than half a mile long (east and west) and is not shown on the wnship plat. The shores have been burnt and are now covered ith a second growth of birch and poplar. This lake is the me hight as Surveyor's lake.

The fine red syenite, similiar to No. 214, occurs in several aces on the portage from Surveyor's lake. On the north side the lake is a hill, 50 feet above the water, composed of a diabase (No. 215). On each side of this hill the red syenite occurs, thus making it seem as if the diabase had cut through the syenite; the two rocks were not seen in contact. The north shore of the lake is mostly made up of the fine red syenite. In one place this syenite held angular pieces (none were seen over three inches in diameter) of a fine dark rock; this is shown by No. 216, which shows both the dark rock and the syenite. In this specimen the syenite is easily seen to contain much quartz: — in the other specimens of this syenite (Nos. 200, 202, and 212) quartz can not be clearly seen with the hand lens.

LAKE IDA BELLE.

This lake is very irregular. It lies in secs. 1, 2, 3, 10, 11, and 12 of T. 63–4, while bays extend a short distance into T. 64–4, T. 64–2, and T. 63–3. It is 30 feet below Found lake. The country around lake Ida Belle, except a small portion at the northeast corner of the lake, has been burnt, and there are vast exposures of rock all around the lake not yet covered by a second growth of trees.

This lake lies in the great gabbro sheet; probably nine-tenths of the rock around the lake is gabbro, the rest being trap and fine red syenite. A belt of iron ore was reported running from sec. 1 to sec. 18, T. 63–4; the entire lake shore was examined, also part of the country southwest of the lake, but no iron ore was found;—in fact the only iron seen consisted of a few bands or seams of magnetite in the gabbro. Fresh beaver cuttings were seen along the shore in sec. 10, T. 63–4. No portage could be found from the last lake to lake Ida Belle, and so one was cut straight north for about one-third of a mile; this brought us to lake Ida Belle near the centre of Sec. 11, T. 63–4.

In the S. W. ¼ of N. E. ¼ sec. 11, T. 63–4, the gabbro (No. 217) occurs and continues along the south shore most of the way to the stream that enters the lake in the S. E. ¼ of sec. 10. In the S. W. ¼ of N. W. ¼ sec. 11, just east of the line between secs. 10 and 11, there is an exposure of diabase (No. 218). The gabbro on the little point in the S. E. ¼ of sec. 10 is cut by a dike of fine diabase (No. 219); the dike runs a little west of north; it is three feet wide and was traced twenty feet. The gabbro at this point is represented by No. 220, which is exactly similar to that found much farther north.

A trip was made south to the corner between secs. 10, 11, 14, and 15 and then west along the line between secs. 14 and 15 for nearly half a mile; the line could be followed no farther, and so we went as near west as possible until two miles west of the above corner. Many rounded hills of gabbro were crossed,—in fact all the rock seen was gabbro except a small outcrop about three-fourths of a mile from the corner; this outcrop consisted of a fine-grained rock (No. 221) which, if it were a little more decayed, would resemble what has been termed "muscovado." One of the specimens collected (No. 222) is from a vein which contained large crystals of hornblende, an inch or more long. In some places there were small patches or seams of gabbro that contained considerable magnetite, as shown by No. 223, but in no place did the magnetite make up more than one-third of the rock. At one place, one and a half miles west of the corner, here was a thin scale, not much more than half an inch thick, of magnetite lying on the gabbro; this extended only about 20 feet; No. 224 is from this scale of magnetite. From the last place one and a half miles west from the corner) Mr. Meeds went orth for half a mile, and found nothing but gabbro. A section was also made south for half a mile; the gabbro was the only ock seen.

Gabbro continues along the north and west shores of the lake n sec. 10; it was examined in several places. There is a very mall bay in the N. W. ¼ of N. E. ¼ sec. 10; on the east side of he entrance to this bay there is an exposure of gabbro sloping down to the water. The surface of the gabbro is spotted with mall and irregular pieces of the fine red syenite (No. 225), and there are veins of this syenite in the gabbro; there is also a large piece of syenite, 10 by 20 feet. This large piece and the smaller pieces of syenite seem to lie on the gabbro; and this, together with the fact that the gabbro is cut by veins or dikes of the syenite, would indicate that *the syenite is of later date than the gabbro.* The top of the gabbro exposure is cut by an irregular dike, which at one end is three feet wide; it then widens out to twelve feet. The direction of the dike is nearly east and west, and it was traced forty feet. The syenite at this place is represented by No. 225, the dike rocks by No. 226, and the gabbro by No. 227. This is the first place that the writer has found the fine red syente in contact with the gabbro. The two are seen in contact again at the northwest corner of this little bay; here the contact s vertical, and is a sharply defined line, but there is only a small four feet wide) strip of syenite exposed.

Many outcrops of gabbro are seen along the west shore of the lake till we reach a small island in the N. E. ¼ of S. E. ¼ sec. 3. On the north side of this island the gabbro and the fine red syenite are again seen in contact; *here the gabbro lies on the syenite*, which is represented by No. 228. A bluff of rock about thirty feet high is exposed; the upper part is composed of gabbro, which projects out beyond the syenite lying below. At the contact the gabbro has crumbled away, so the actual contact line could not be seen, but the two rocks were found within an inch of each other. There seems to be no change in either rock near the contact.

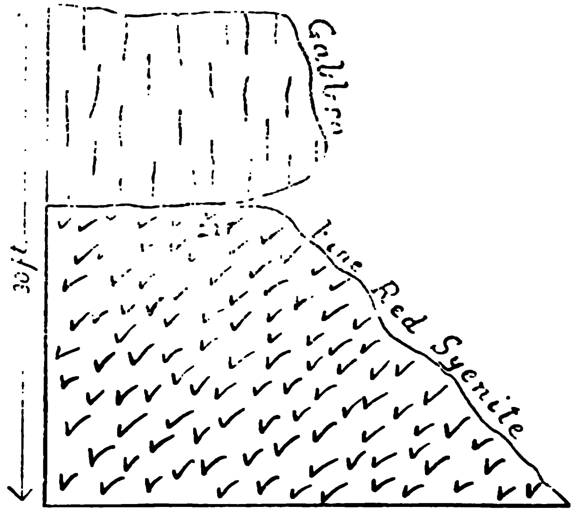

Fig. 4. Gabbro lying on fine red syenite, lake Ida Belle.

In the N. E. ¼ of S. E. ¼ and S. E. ¼ of N. E. ¼ sec. 3, T. 63-4, just north of the island mentioned above, there is a hill composed of a dark fine-grained rock (No. 229). This is cut through and through by numerous, irregular, branching veins of the fine red syenite (No. 230); these vary from two feet to half an inch in width, and even run out to needle-points. No. 229 seems to be a syenite, like the red syenite, but the hornblende makes up so large a part of it that the rock appears almost black. It is different from the dark rock seen in the syenite on the north side of Found lake. No. 231 shows Nos. 229 and 230 in contact; the contact is a distinct and sharply defined line, and in no place were the two rocks found to grade into each other.

The rest of the lake shore was examined; gabbro was found in ny places, especially along the eastern shore. On the west re, near the centre of sec. 2, T. 63–4, were two exposures of . 229 cut as above described by fine red syenite similar to No. . At the extreme northeastern corner of the lake, in the S. W. ¼ sec. 31, T. 64–3, the red syenite again occurs. At the portage E. ¼ of sec. 35, T. 64–4) going north from lake Ida Belle the bro was cut by veins of fine red syenite (No. 232).

FROM LAKE IDA BELLE TO OGISHKE-MUNCIE LAKE.

arrow lake. This is a narrow irregular lake in secs. 25, 26, and 36 of T. 64–4; it is a mile and a half long (north and th), but not more than a quarter of a mile wide. It is 15 feet ow lake Ida Belle. The shores are densely wooded, the ber being mostly spruce, birch and jack pine. The portage n lake Ida Belle is in the S. E. ¼ of sec. 35; it is well cut and y about an eighth of a mile in length. Gabbro occurs on the t shore in the N. E. ¼ of sec. 35. On the west shore (S. E. ¼ . E. ¼ sec. 26) near the north end of the lake is what seems e a decayed condition of the gabbro (No. 233); this contains siderable biotite.

iskadinna lake[*]. This lake is mostly in sec. 24, T. 64–4 and . 19 and 20, T. 64–3. It is 25 feet below Narrow lake. The res are densely wooded. The northern arm, which is in the . ¼ of sec. 13, T. 64–4 and the N. W. ¼ of sec. 19, T. 64–3, hown on the plat as a separate lake, but it is only an arm of kadinna lake. There are two short portages from Narrow to this lake along the stream that connects the two lakes. many rock exposures are to be seen along the shores of this ; all those examined were gabbro. Gabbro also occurs on south shore of the northern arm where the line between ges 3 and 4 touches the shore.

iskadinna lake to Round lake. In the N. W. ¼ of S. E. ¼ sec. T. 64–4 there is a short portage from Kiskadinna lake past a ids in the stream[†] that flows from this lake through secs. 13, 10, 3, and 2 of T. 64–4 into Round lake which is in the S. W. sec. 35, T. 64–5. There are three rapids along this stream re short portages are made—in the N. W. ¼ sec. 13, S. W. ¼ 11, and N. W. ¼ sec. 2,—this last portage coming to Round lake. The stream is easily canoeable, being usually from 100 to 1,000 feet wide. The portages are well cut and seem to be used considerably in the winter time. The only rock seen along this stream was gabbro; this occurred in several places, as follows: near the centre of sec. 13, S. E. ¼ of sec. 11, on the portage in the S. W. ¼ of sec. 11, N. E. ¼ of sec. 10, S. W. ¼ of sec. 2, N. W. ¼ of sec. 2, and on the portage in the N. W. ¼ of sec. 2. Round lake is 60 feet below Kiskadinna lake.

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[*] This name is taken from Heinze Brothers "Map of the Vermillion Iron Range."

[†] This stream finally enters Gunflint lake at its western end.

Draper lake. This is a somewhat circular lake in the W. ½ of sec. 34 and the E. ½ of sec. 33, T. 65–4. It is 35 feet above Round lake. A portage of about half a mile connects these two lakes; it leaves Round lake at its northwestern corner. The gabbro occurs in several places along this portage. There are also many fragments of quartzyte on the portage, but no rock was found in place; these are probably from what has been termed Pewabic quartzyte found a short distance north of here. On the western shore of the lake, in the N. E. ¼ of sec. 33, there is an exposure of a muscovado-like rock (No. 233½).

Draper lake to Flying Cloud lake. From Draper lake we went through six small lakes to Flying Cloud lake. This plat (T. 65–4) is very inaccurate, and the route we took and the position of the lakes could not be definitely determined. Below, the lakes have been numbered from one to six, and the location given as near as possible.

Lake No. 1:—Near the centre of sec. 33, T. 64–5. Forty feet above Draper lake.

Lake No. 2:—N. W. ¼ of sec. 33, T. 64–5, not shown on the plat. Same hight as lake No. 1.

Lake No. 3:—This is probably Charley lake, which is in the N. ½ of sec. 32, T. 65–4. Fifteen feet above lake No. 2.

Lake No. 4:—Centre of sec. 29, T. 65–4. Not shown on the plat. Forty feet above lake No. 4. On the west side of the portage (this portage runs nearly north) from lake No. 3 there is a bluff 25 feet high and over 100 feet long; the front of the bluff is perpendicular. At the base near the centre there is a fine gray syenite (No. 234), forming the first eight feet of and extending for 25 feet along the foot of the bluff. Directly over the syenite and lying on it is the gabbro (No. 235) which composes most of the bluff. The change from the gabbro to the syenite was abrupt, there being no transition. The contact line was not easily seen as the face of the bluff was covered with lichens, but on chipping off small pieces of the rock the syenite and gabbro

rithin an inch of each other. The syenite is very
than the Saganaga syenite found on the north shore
lake. Just across the portage-trail from this bluff
ınd gabbro there is one exposure of "muscovado"
imilar to No. 233½. A little island in the southern
e No. 4 is made up of a fine gabbro (No. 237) that
ntain considerable olivine.

5:—E. ½ of sec. 30, T. 65–4. Not shown on the plat.
ıall lake, not more than a quarter of a mile across.
as lake No. 4.

6:—S. W. ¼ of sec. 30, T. 65–4, and S. E. ¼ of sec.
25 feet below lake No. 5.

'oud lake:—This lake is about a mile in length, and
3. ½ of S. ½ of sec. 25, and a small portion is in the N.
. 36, T. 65–5. 30 (?) feet below lake No. 6.
ıuth shore near the east end of the lake (S. E. ¼ of S.
) there is a low ridge of dark, almost black, quartz-
; east and west. This quartzyte stands vertical, and
as near as could be estimated without the needle,
ıre much disturbed, is about east and west. The bed-
y plainly seen, especially on the weathered surfaces;
ıed by bands, which contain varying proportions of
inerals of the rock,—quartz* and magnetite. The
ɔollected (No. 238) fairly represent the rock, which is
nagnetite that it would make a fair iron ore. The
xposure is in a vertical north facing wall, 12 feet high
long, but several other smaller exposures are seen for
t of this. At the foot of the ridge is an outcrop of
(No. 239). It seems as if the quartzyte overlies the
but this could not be positively determined (how-
s found to be the case about a mile west of this point).
zyte is the Pewabic quartzyte described in the 16th
ort, and the greenstone is probably the same as that
in connection with the quartzyte.

lying Cloud lake we went southwest for about two
; a stream—making four short portages—to Kakego
the north side of this stream, a short distance west of
rtage from Flying Cloud lake (probably in the S. E.
sec. 26, T. 65–5), the Pewabic quartzyte again occurs;
ılly as rich in iron as seen at any other place. This

ɔrobable that there is also olivine in the rock.

is shown by No. 240. It dips south about 40°. Twelve feet north of this quartzyte is a low outcrop of greenstone (No. 241); this is much darker and heavier than No. 239 and apparently contains considerable iron. The position and dip of the quartzyte would bring it over the greenstone. The contact between the two rocks was covered by soil. On the south side of the stream is a ridge, 50 feet high, of the quartzyte dipping south about 50°. No. 242.

On the east end of the second portage from Flying Cloud lake the quartzyte is again seen; here it dips south 45°. On the west end of the portage the quartzyte is found lying on the greenstone (see Fig. 5). This is probably in the N. W. ¼ of N. E. ¼ sec. 35, T. 65–5. The contact is abrupt and there is no transition from one rock to the other. Both rocks seem to be unchanged near the contact, except that the greenstone is a little decayed. The Pewabic quartzyte, dipping south 45°, is shown by No. 243, which was taken within six inches of the contact. The greenstone is shown by No. 244; this seems to be similar to No. 239.

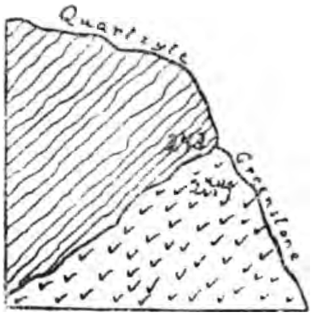

Fig. 5. *Pewabic quartzyte lying on greenstone, N. W. ¼ of N. E. ¼ sec. 35, T. 65–5.*

SHOO-FLY LAKE.[*]

This lake is in the S. E. ¼ of sec. 11 and the N. E. ¼ of sec. 14, T. 64–7. On the little point, in the N. E. ¼ of N. E. ¼ sec. 14, there is a fine-grained condition of the gabbro (No. 245), and on the east side of the lake near the southern end there is a precipitous cliff of the same rock rising 50 feet above the water,

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[*] The following notes were taken on a trip from Knife lake through Kekequabic, Shoo-fly, Fraser, Thomas, Alice and Wilder lakes, thence along the Kawishiwi river to the S. E. ¼ of sec. 8, T. 62–9, and then through Gull lake to Mishiwishi lake.

Shoo-fly lake a portage of a third of a mile runs south to
lake, not shown on the plat, in the S. W. ¼ of sec. 13, T.
On the west side of this lake near the northern end there
tcrop of gabbro (No. 246); this is finer than the ordinary
On the west side of the lake near the southern end is
outcrop of gabbro (No. 247) which seems to be a decayed
n of No. 246. From the southern end of this lake a por-
s south for about a third of a mile and reaches Fraser
the N. W. ¼ of N. W. ¼ sec. 24, T. 64–7.

FRASER LAKE.

r lake is mostly in secs. 22, 23 and 24 of T. 64–7. On the
de of the lake in the S. E. ¼ of S. W. ¼ sec. 14, T. 64–7
re several exposures of iron ore;* these were examined
arefully. About 150 yards north of the shore, where it
y the line between secs. 14 and 23, is a small pit, four
p. At the bottom of this pit is found quite a rich oli-
iron ore (No. 248); this disturbs the needle but slightly
ms to be mostly menaccanite rather than magnetite. On
h this comes in contact with a wall of rock (No. 249) com-
f large crystals of hornblende (?) that is almost fibrous;
here are parallel bands of iron ore (Nos. 250 and 251)
un east and west and dip south about 80°. No. 250 is
to the ore in the pit, while No. 251 is distinctly a mag-
artzyte and shows the bedding plainly. A few rods
st of this pit, and at the top of the steep northward slope,
er exposure of olivinitic iron ore (No. 252); this appears
to the ore in the pit, but affects the needle very strongly,
bably being mostly magnetite. This mass of iron ore at
ern edge comes into direct contact with a hornblende
o. 253) which is a less decayed condition of No. 249. The
nde rock is here also in contact with a fine "muscovado"
4) which shows a few large crystal faces of feldspar, half
or more in length. Very little of these two rocks was
d their relation to each other was not determined. The
line is irregular and there is no transition from one to
r, nor is there any sign of alteration in either rocks near
tact. A few small areas in this hornblende rock were
ch in iron, as shown by Nos. 255 and 256, but the limits
e areas were rather sharply defined. The observations

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s the place where an attempt was made to mine for gold several years ago.

were made on a ridge which runs east and west; it was examined for 100 yards on each side of the above mentioned pit. The north side of the ridge is rather steep and at its foot occurs the muscovado, here represented by No. 257. As far as exposed the top of the ridge is composed of the hornblende rock (Nos. 249 and 253); this holds many masses and bands of magnetitic quartzyte. The bedding in the quartzyte is usually very distinct; in all the places examined it runs east and west, but within ten feet the dip varies from the vertical to about 45° south. The masses of iron ore where Nos. 248 and 252 were obtained contain very little quartz and show no evidence of bedding. The line of contact between the quartzyte and the surrounding rock is usually distinct and very irregular; there was no blending of the two rocks. No. 258* shows the quartzyte, and in the specimens numbered 259 the bedding is plainly seen. No. 260 shows the contact of the quartzyte and the surrounding rock.

In the N. W. ¼ of N. E. ¼ sec. 23, about a quarter of a mile west of the previously described locality, is a ridge running east and west; this is probably an eastward continuation of the ridge mentioned above. On the south side near the base of the ridge and about 50 feet from the lake a rather fine, decayed, gabbro-like rock (No. 261) occurs; this is exposed in several places; it has a rough bedded structure (the beds being from 6 to 12 inches thick) which is nearly horizontal. On the north side of the ridge and near its foot is a small exposure of iron ore (No. 262); it has a tendency to split along parallel plains which are vertical and run east and west. Within ten feet of this ore the quartzyte is seen. The ridge at this place is made of quartzyte which was followed eastward for 50 yards, where the ridge ends abruptly. The bedding is very nicely seen along the weathered surfaces; it is caused by bands of almost pure quartz alternation with bands rich in magnetite. Some of these bands are shown by Nos. 263, 264 and 265. Throughout the fifty yards that the quartzyte was followed, except in one small area where the beds had been broken and bent, the strike and dip were constant, the former being almost east and west, and the latter south 75°. At the eastern end of the ridge a band two feet wide, of a fine muscovado-like rock (No. 266) occurs interbedded with the quartzyte; this rock was traced for over 30 feet; it has a tendency to a rough cleavage which is parallel with the quartzyte bedding. On the h side of the ridge, but not within 30 feet of any quartzyte, lso found an outcrop of the iron ore (No. 267) which has thered into thin parallel sheets conformable with the rtzyte.

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*No. 268 was taken from the quartzyte near this; it is a bunch of the crystals of the hornblende rock, but they seem to be mostly magnetite.

he quartzyte described at these two localities on Fraser lake ecidedly like the Pewabic quartzyte. Evidently the gabbro, ch covers this section of country, has been worn away and a ch disturbed portion of the underlying quartzyte exposed. quartzyte was not seen in contact with, nor in fact near any he ordinary labradorite gabbro, but this gabbro has been n on all sides of it at places usually less than a mile distant.

THOMAS LAKE.

This lake is in secs. 27, 28, 29, 32, 33 and 34 of T. 64–7, and s. 5 and 6 of T. 63–7. There is some good white pine along southern shore of the lake; several claim cabins were seen re.

The iron ore, shown on the map (in the 15th annual report) as curring on the north side of the lake in secs. 27 and 28, was t found, although the locality was carefully examined. The ly iron seen was a small amount of menaccanite in the gab o (No. 269); this specimen was found about a quarter of a ile north of the lake in the N. E. ¼ of sec. 28.

On the north side of the mouth of the little bay, which is near e centre of the W. ½ of sec. 27, there is a bluff 40 feet high, muscovado (No. 270) holding irregular blotches of a light lored feldspar.

On the lake shore in the N. E. ¼ of sec. 29, on a little point at is about half way between the meander corner on the line etween secs. 28 and 29 and the stream that flows toward Ima ke, is a low outcrop of rock (No. 271) similar to the hornlende rock found at Fraser lake. Here were many angular agments of quartzyte (similar to the Pewabic quartzyte); one pecimen (No. 272) was taken to show how plainly the banding ppears on a weathered surface. A few feet back from the hore is an outcrop, two feet high, of magnetic iron ore (No. 78);[*] this is composed of almost pure magnetite with a little livine. This ore was not seen in contact with any other rock, ut it contains a few of the crystals that make up the hornblende rock. No bedding could be seen. On farther search a low outcrop of quartzyte, similar to that seen at Fraser lake, was found about 50 yards from the shore. By pulling away the moss and soil this rock was exposed for twelve feet. It lies nearly horizontal, dipping south about 10°. Nos. 274 and 275 show this quartzyte. As the shore at this point is low and there is very little rock exposed, the relations of the hornblende rock, the iron ore and the quartzyte could not be determined.

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[*] This is probably the ferruginous gabbro mentioned in the 15th annual report, page 360, but hammer marks were seen here. (It was this which was intended to be represented on the N. H. W.)

LAKE ALICE.

From the extreme southwestern corner of Thomas lake a portage, of less than a quarter of a mile, leads southwest to Gabiskamak* lake, which is an irregular lake lying in sec. 6 of T. 63-7. The shores of this lake, except a small portion at the northern end, have been burnt and are now partially covered by bushes 8 to 10 feet high. There were many rock outcrops along the shores: all of those visited were gabbro, and the others appeared to be the same.

From the south end of Gabiskamak lake a portage of half a mile leads south to the arm of Wilder lake that extends into the S. E. ¼ of sec. 7, T. 63–7. Gabbro was seen in several places on the portage; also on the west shore of the arm of Wilder lake. The north shore of the Kawishiwi river was examined from Wilder lake to lake Alice; no rock was seen except gabbro and there were many exposures of this. Between these two lakes both shores of the river have been burnt and are now covered with small birches, poplars and jack pines.

Lake Alice lies mostly in secs. 9, 10, 15, 16 and 21 of T. 63-7. It is four feet above Wilder lake and is connected with it by two miles of river in which there is one fall; this is in the N. E. ¼ of N. W. ¼ sec. 20, T. 63–7. The Chippewa name for this lake is Pe-na sagiagan or Partridge lake. The island crossed by the line between secs. 9 and 16 has not been burnt; also the N. W. ¼ of S. E. ¼ sec. 15, where there is a claim cabin and some Norway pine. The rest of the shore has been burnt and is now covered with young birches, jack pines, and poplars. From the end of the bay in the N. W. ¼ of sec. 22 there is a portage leading east; there is also one, leading east, leaving the lake in the N. W. ¼ of S. E. ¼ sec. 10. From the extreme northern end of the lake a short ıge leads to a small lake, on the south shore of which the ıro is exposed. Lake Alice, and especially the eastern side, rather carefully examined, stops being made about every 200)0 yards (the bay in the N. E. ¼ of sec 9 was not entered); no was found except the ordinary labradorite gabbro; this was in very many places; No. 277 is a sample from the S. E. ¼ . W. ¼ sec. 15. In one place on the east side of the long bay :c. 15 the gabbro (No. 276) is of a decidedly pinkish color; labradorite crystals have a pinkish tinge and there are :hes of a very soft, brick-red mineral, probably an oxide of Search was made back from the shore for more of this : gabbro, but none was found.

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*This is the Chippewa name of the lake; I do not know its meaning.

LAKE ALICE TO MISHIWISHIWI LAKE.

ıe bay of Wilder lake which lies in sec. 13, T. 63-8, was not red by the survey two years ago; and so it was examined on trip; no rock was seen except the gabbro.

rom Wilder lake the Kawishiwi river was followed to the e bay in the N. W. ¼ of S. E. ¼ sec. 3, T. 62-9; here a por- ı of about two miles was made southeast to Gull lake. There is)ortage route through this way,—only a very poor trail which sed by the Indians in their winter trapping. On the way ›e ponds were crossed; one in the S. ½ of sec. 3, T. 62-9, one the N. E. ¼ of sec. 9, and one on the line between secs. ıd 16;—no rock exposures were seen on these ponds, but :e were exposures of gabbro in the N.W. ¼ of sec. 10 and the V. ¼ of sec. 16.

ull * lake is a narrow body of water extending northeast and :hwest in sections 16, 17, 19 and 20 of T. 62-9. The shores closely covered with spruce and jack pine. The west side of lake was examined; all the rock seen was the ordinary gab- . From the southwest corner of this lake a fair portage, over ile in length, leads southwest and reaches Mishiwishiwi lake ıre the line between secs. 24 and 25, T. 62-10 crosses the re. Gabbro occurs along this portage.

PINE ISLAND, VERMILION LAKE.

. section was made across Pine island, on the line between ;es 15 and 16, in order to examine a hill of jasper reported

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* The Chippewa name is Gaiashk (Gi-äshk) sagaigan or Gull lake.

to be there. The writer crossed the island on this line and also went west from the line for a mile, near the centre of the island, but found no jasper hill, nor any indications of jasper. The rocks seen on the section across the island are given below.

At the north side of the island is a hill, rising 40 feet above the water; this is made of vertical, rather siliceous, sericitic schist (No. 284); the strike is E. 15° N. From this hill a swamp, where there are no rock exposures, extends for nearly one-fourth of a mile south of the corners of T. 62–15. 62–16, 63–15 and 63–16. At the south end of the swamp is a low (six feet high) ridge of sericitic schist (No. 285); strike E. 20° N., vertical. Just north of the quarter post there are three ridges running east and west. The first ridge is composed of a greenish rock, which on the north side of the ridge is quite schistose and somewhat sericitic (No. 286): strike E. 10° N., vertical; on the south side the rock is more massive and graywacke-like (No. 287). The second ridge is made of a rough sericitic schist (No. 288); strike nearly east and west, vertical. No. 289 is from the third ridge; it is harder, greenish, and perhaps somewhat chloritic. South of the quarter post, and about an eighth of a mile from the lake, the following rocks were seen; strike E. 15° N., vertical. No. 290, light gray argillaceous slate; Nos. 291, 292 and 293, coarser and rather sericitic conditions of the same; Nos.294and295, light gray arigllaceous slate. No. 296 shows a more siliceous condition of the slate. At the lake shore there are fine argillaceous slates* (No. 298); these vary from black to gray; the slaty structure and the black and gray bands are parallel; strike E. 15° N., and dip 80° to the north. No. 297 shows the gray slate a few feet from the shore.

III. SUMMARY.

No generalization or theories would here be in place, but it may, perhaps, be admissable for the writer to give a very brief summary statement of the bearing of some of the facts in the foregoing notes upon the general geology of the region traversed. The following remarks relate, more or less, to the great gabbro sheet, which covers so much of that part of Minnesota north of lake Superior.

The fine red syenite, or "red rock" of former reports, was seen in several places on lake Ida Belle in contact with the gabbro. In one place (see fig. 4) the gabbro was in contact with and was unquestionably overlying the syenite; but in other places veins and dyke-like forms of what certainly appears to be the same syenite cut through the gabbro. The syenite has the appearance of an eruptive rock, and the general impression left on one, by seeing the outcrops on this lake, is that the syenite is of more recent date than the gabbro. The two rocks are very distinct and in no place were seen to grade into each other; where they were seen together the contact was a well defined line.

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*Mentioned in 15 An. Rep., p. 303; No. 921.

The syenite found on the gabbro at Winchell lake is not the same as that just mentioned.

The iron ore and magnetic quartzyte (of which the ore is a part) found at Fraser and Thomas lakes are undoubtedly disturbed portions of the Animike beds now included in the gabbro. It is probable that they have not been moved far from their original position, and that, consequently, at this place the gabbro sheet is of a comparatively small thickness. It seems that all the ore at this place is from the quartzyte and that that portion which is but slightly magnetic has become charged with titanium from the gabbro. In connection with this quartzyte is found a peculiar rock that is made up of coarse and almost fibrous crystals of what is probably hornblende. This rock, as far as the writer knows, has been found in this region nowhere except in connection with this quartzyte and then only when the quartzyte was close to or in contact with the gabbro. The quartzyte south of Birch lake, at Chub (Akeley) lake and at Thomas and Fraser lakes also shows this.

IV. List of, and Notes on, the Typical Rocks of Each of Which 25 Specimens Were Collected.

These specimens are, in many cases, from the exact spot from which the original specimens were collected and described, the writer having visited many of these localities with Prof. Winchell on two of his trips through this region. Some of the specimens from localities, not before visited by the writer, may not always be exactly the same as the original specimens, but they are very nearly the same,—as near as could be found from the notes given him. Only brief descriptions of many localities were accessible in the field, as the 16th annual report had not then been printed.

After each number the place where the original description can be found, is given.*

No. 744, (84):—Ogishke-Muncie conglomerate from Camper's island, Ogishke-Muncie lake; S. E. ¼ of S. W. ¼ sec. 23, T. 65–6. The specimens were taken from the southwest corner of the island. They show the matrix of the conglomerate, with sometimes a few of the smaller pebbles. The specimens collected are coarser and not as green as the original No. 744. 10th An. Rep., p. 91.

No. 751:—Hornblende porphyry, S. E. ¼ of sec. 30, T. 65–6; Kekequabic lake. No specimens of this were collected, as the rock was not found in place by the writer. It is similar to No. 1059 (97), except that the ground mass is inclined to brownish while No. 1059 is yellowish green. See No. 1059 10th An. Rep., p. 92.

No. 868, (278):—Green chloritic schist embracing fragments of jaspilyte, north of Cady house, Tower. This rock evidently grades into No. 908 (281). 15th An. Rep., p. 267–8.

No. 892, (279):—Rough, scarcely banded jasper, north wall Stone mine, Tower. Owing to changes in the walls of the mine, this rock was not seen 75 feet below the surface; the specimens collected were taken about 25 feet below the rock surface. 15th An. Rep., p. 256.

No. 903, (280):—Red jasper with darker bands of iron ore; Stone mine, Tower.

No. 908, (281):—Matrix of conglomerate occurring north of the Cady house, Tower. 15th An. Rep., p. 269.

No. 916, (282):—Breccia, now converted to hematite and a floury white mineral; Breitung mine, Tower. 15th An. Rep., p. 250.

No. 921, (283):—Black or purplish-black clay slate, S. W. ¼ of S. W. ¼ sec. 6, T. 62–15; south shore of Pine island, Vermilion lake, a few feet east of the line between ranges 15 and 16. See notes on Pine island in this report. 15th An. Rep., p. 303.

No. 950, (128):—Siliceous schist or bedded quartzyte from "Silver City," N. E. ¼ of sec. 32, T. 63–11. The specimens were obtained from the shore, forty feet nearer the rapids than the southern tunnel is. 15th An Rep., p. 329.

No. 954, (114):—Coarse gabbro, east side of Birch lake. The specimens were taken from the same exposure from which the

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*These are the numbers given by Prof. Winchell in the 10th, 15th and 16th annual reports. The numbers in parentheses and all under 300 are those given by the writer.

inal specimen came. In the description (16th An. Rep.)
locality is given as the N. W. ¼ of sec. 20, T. 61–11, and in
catalogue of rock samples as the N. W. ¼ of Sec. 17. Judg-
from distances to known points (this town has not been
reyed) the writer thinks that the N. W. ¼ of sec. 17 is the
it place. 15th An. Rep., p. 332.

o. 958, (121):—Breccia of mica-schist cemented by granite
n the little point in the N. E. ¼ of S. E. ¼ sec. 21, T. 61–12,
ch lake. Where the mica-schist showed the schistose struc-
e to the best advantage, the rock was too much decayed for
d specimens. 15th An. Rep., p. 333.

o. 960:—See No. 1138.

o. 963, (123):—Fine-grained red syenite, resembling the
d rock" of Grand Marais, from the S. W. ¼ of S. W. ¼ sec.
T. 61–12, Birch lake. The specimens were collected just
t of the line between secs. 23 and 24, and about 300 feet back
m the lake shore. 15th An. Rep., p. 336.

o. 979, (111):—Fine syenite from the "Palisades," N. W. ¼
S. W. ¼ sec. 4, T. 62–10. The specimens are from near the
thern end of the "Palisades" and about 20 feet above the
ter. The rock varies some and has an almost gneissic struc-
e. The specimens collected represent the prevailing variety;
s grades into No. 112, which is gray, and into No. 113, which
oarser. 15th An. Rep., p. 342.

o. 989, (101):—Fine grained, slightly micaceous quartzose
k from the south shore of the Kawishiwi river in the N. W. ¼
N. W. ¼ sec. 27, T. 63–10. 15th An. Rep., p. 352.

o. 991, (102):—Gray, red-weathering gneissic rock from an
nd in the N. W. ¼ of N. W. ¼ sec. 27, T. 63–10, Kawishiwi
er. The southern part of the island is composed of this rock,
on the central and northern parts the rock has many darker
nblendic bands which show very plainly on the weathered
face (No. 103). One much darker hornblendic band, about a
t in width, was seen; this (No. 104) seemed to be distinct
m the others, which graded into one another. No. 991 also
wed banding on weathered surfaces. 15th An. Rep., p. 352.

o. 994, (105):—Reddish chloritic syenite; N. E. ¼ of N. W. ¼
27, T. 63–10; south shore of Kawishiwi river. This rock is
dly a red syenite like the original No. 994, but in places it is
dish,—see No. 107, which is similar to the original No. 994;
enough of this reddish rock could be found for the speci-
s. This rock (No. 105) seems to grade into No. 108 and

No. 109; the latter has some biotite and the exposures show a rather distinct bedding, while the exposures of No. 105 do not. Lenticular pieces of a greenish chloritic schist (No. 110) are found in a few places in No. 105. 15th An. Rep., p. 353.

No. 1044. (85):—Gneissic (syenitic?) rock, south shore of the little bay at the southeast side of Kekequabic lake, S. E. ¼ of S. W. ¼ sec. 2, T. 64–7. The specimens were taken from the only outcrop, on the south side of this bay, where hammer marks were seen. The rock contains many small dark masses, apparently chloritic, as shown by No. 85; none of these were over an inch in diameter. In a few places this dark mineral is collected into rather indistinct vein-like forms, but there is no marked contrast between these "veins" and the surrounding rock. 15th An. Rep., p. 361.

No. 1049. (87):—Biotite gabbro, somewhat pebbly, east side of sec. 4, T. 64–7, Kekequabic lake. The water was so high that the specimens could not be collected in the bay in the east side of sec. 4, so they were taken from the N. E. ¼ of the S. E. ¼ of sec. 4; here the rock seems to be the same as in the bay. The pebbly structure of the rock is shown only where it has been water worn. At this place the gabbro lies on some gray earthy slate. The slate was down at the water's edge and there was only a very small area of it, so not much could be determined concerning it. No abrupt contact could be seen between the two rocks; there was a transition, occupying perhaps two feet, from the gray earthy slate (No. 88), through Nos. 89 and 90, to the gabbro (No. 87). 15th An. Rep., p. 364.

No. 1050. (91):—Fine-grained gabbro from the top of the same bluff, as from which No. 1049 was taken. The specimens were taken about 35 feet above the water. N. E. ¼ of S. E. ¼ of sec. 4, T. 64–7, Kekequabic lake. 15th An. Rep., p. 364.

No. 1059. (97):—Hornblende porphyry from the north shore of Kekequabic lake, N. E. ¼ of sec. 36, T. 65–7. Within a few inches this rock varies much, the hornblende crystals becoming smaller and fewer in number and sometimes almost wanting, as shown by the small specimen No. 97A. The rock is very hard and tough and rings like iron when struck by the hammer; it frequently contains crystals of iron pyrites. See No. 751. 15th An. Rep., p. 367.

No. 1068. (70):—Doleryte, from N. E. ¼ of sec. 24, T. 65–6; about a quarter of a mile southeast from the shore of Ogishke-Muncie lake. This rock contains considerable of a pinkish min-probably calcite); this mineral also occurs in small veins sures in the rock, shown by No. 71. 15th An. Rep., p. 371; 16th An. Rep., p. 95–6.

. 1073, (69):—Coarse-jointed massive rock, apparently us, mouth of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. . 65–6; Ogishke-Muncie lake. This rock overlies the fol- g, which see. In some places the rock has cherty spots, as n in the smaller specimen (No. 69), probably pieces of the (No. 1074). 15th An. Rep., p. 372.

. 1074, (68):—Fissile black slate, baked and closely jointed, h of Ogishke-Muncie creek, N. E. ¼ of S. E. ¼ sec. 26, T. Ogishke-Muncie lake. No specimens could be obtained at ontact with the overflowing rock (see above, No. 1073), as the slate was much broken; the specimens collected are the point made by the creek and the lake shore, which is but a few yards west of No. 1073. At this place the plainly dips 20° S. of E. at an angle of about 80°. No. 68A obtained just below the contact, while No. 68 B is from a of the slate included in the overlying rock. The slate has, aces, a decidedly conchoidal fracture as shown by No. 68C. weathered surfaces on the specimens marked 68 show an rently sedimentary banding which is parallel with the slaty ture. 15th An. Rep., p. 372.

. 1094, (86):—Gray porphyritic rock, representing an altered lomerate, from the point which has the corners of secs. 29, 1, and 32, T. 65–6; north shore of Kekequabic lake. The imens were taken from the southeast side of the point, or in . W. ¼ of N. W. ¼ sec. 32, T. 65–6. No. 86 shows a small of the greenish nodules or pebbles. 15th An. Rep., p. 368; An. Rep., p. 100.

. 1098, (96):—Conglomeritic chlorite schist, from the north e of Kekequabic lake where it is crossed by the line between -6 and 65–7. The small amount of the rock left uncovered by orphyry and its decayed condition made it rather difficult t good specimens. 15th An. Rep., p. 367.

. 1100, (93):—Reddish syenite, island in sec. 3, T. 64–7, quabic lake. No. 1100 is described from the most westerly l in the lake, but this island, which is just east of the point S. W. ¼ of N. W. ¼ of sec. 3, is small and low and is made a condition of the green chlorite schist (No. 94); the small just northeast of the last, seems to have no rock in place, ng the shore are many fragments of feldspar porphyry

(No. 95). The specimens (No. 1100) were taken from a larger island in the S. E. ¼ of N. W. ¼ sec. 3, just west of Animike island. 15th An. Rep., p. 362.

No. 1109, (100):—Felsitic schist, from the portage from Fall lake to Newton lake, S. W. ¼ of sec. 3, T. 63–11. The specimens were collected from the south, or Fall lake, end of the portage. 15th An. Rep., p. 356.

No. 1128, (129):—"Gabbro" cut by intrusive syenite: N. W. ¼ of S. E. ¼ sec. 6, T. 62–11, White Iron lake. See No. 1129, 15th An. Rep., p. 331.

No. 1129, (130):—Intrusive granite (syenite), N. W. ¼ of S. E. ¼ of sec. 6, T. 62–11, White Iron lake. Nos. 1128 and 1129 are from the place frrom which Dr. Wadsworth took the original specimens. The "gabbro" is not similar to the ordinary labradorite gabbro; it is perhaps a biotitic diabase. No. 131 is the syenite taken from a dike in the diabase. No. 1129 (130) is, I think, a fair sample of the syenite found about White Iron lake. 15th An. Rep., p. 331.

No. 1132, (127):—Black hornblende gneiss, east shore of White Iron lake, just south of the line between secs. 6 and 7 of T. 62–11. A set of specimens could not be obtained, as the gneiss only occurred in small masses in the syenite and here the surface was worn smooth by glaciation. No. 127 shows the contact between the gneiss and the syenite. 15th An. Rep., p. 331.

No. 1134, (124):—Micaceous "gabbro," or rather biotite hornblende schist, cut by veins of granite (syenite): N. W. ¼ of S. E. ¼ sec. 12, T. 62–12, east side of White Iron lake. The specimens were collected from the place where Dr. Wadsworth obtained the original ones. About 70 yards west of this place is the outcrop described by Dr. Alex. Winchell in the 15th annual report (see p. 77, halt 211). Here the hornblende schist is represented by No. 125, and the granite by No. 126. These two outcrops are connected by a ridge, in which the rock is not exposed, but the schist found at the east end (No. 124) is probably the same as that at the other end (No. 125). 15th An. Rep., p. 331.

No. 1137, (122):—Fine-grained gabbro, looking like diabase, from a point a short distance west of the line between secs. 24 and 25, T. 62–12; north shore of Birch lake. This seems to be a finer grained condition of the ordinary labradorite gabbro. The specimens were obtained from the west side of the little bay in the S. E. ¼ of S. W. ¼ sec. 24. 15th An. Rep., p. 332.

io. 1138. Ferruginous olivine rock, about 15 rods from the
re; S. E. ¼ of S. W. ¼ sec. 24, T. 62–12; Birch lake. No speci-
ns of this were collected, as a set of 25 (No. 960) was col-
:ed in 1886. It is a part of the great quartzyte formation
nimike) lying along the southern side of the Giant's range.
h An. Rep., pp. 332 and 335.

'o. 1278, (8):— Kewatin schist, mouth of the creek, east end
he long bay, north side of Gunflint lake. This is the most
tern exposure of the Kewatin on Gunflint lake. The rock at
shore was so cracked and broken that only four specimens
re collected; these are marked 1,278A (8A). The rest of
specimens were taken from a low outcrop about 10 rods back
m the shore; the schist here is similar to that at the shore, but
not so much decayed and is apparently more siliceous. 16th
ı. Rep., p. 67.

No. 1282, (9):—Gray gneissoid rock, slightly porphyritic;
re of the long bay, north side of Gunflint lake. The speci-
ens collected do not answer exactly to the description, but
ey are a part of the same rocks. 16th An. Rep., p. 68.

No. 1283, (10):— Porphyrel; bluff north shore of Gunflint lake.
e specimens were taken from a vertical cliff on the lake shore,
out three-fourths of a mile west of the east end of the long
y. 16th An. Rep., p. 68.

No. 1312, (60):—Fine-grained trap, from the west side of the
rrows of Gunflint lake; S. E. ¼ of N. W. ¼ of sec. 19, T. 65–3.
places this trap holds crystals of feldspar which sometimes are
inch long.

No. 1316, (46):—Syenitic gneiss from the north side of Black-
bay, Gunflint lake. 16th An. Rep., p. 73.

No. 1318, (61):—Diabase dike in the syenite, first falls of
ınflint river, north of Gunflint lake. See this report under
ınflint lake.

No. 1340, (43):—Purplish-gray, vitreous quartzyte (Pewabic
artzyte), ½ mile west of the ore pit, Chub lake; N. E. ¼ of sec.
, T. 65–4. 16th An. Rep., p. 85.

No. 1371, (72):—"Marble" from east side of Ogishke-Muncie
ke; N. E. ¼ of sec. 24, T. 65–6. The place where the speci-
ens were collected is probably where the section (p. 371, 15th
ı. Rep.) was made. No. 73 shows a softer, more schistose por-
n of No. 72. No. 74 are some of the angular pieces included
No. 72. No. 75 shows a soft greenish (probably talc) mineral
ınd in the "marble" (No. 72). 16th An. Rep., pp. 95 and 96;
o, under No. 1069, 15th An. Rep., p. 371.

No. 1409, (92):—Chloritic schist from the small islan the north shore and just west of the narrows of Kekequabi This island is in the N. W. ¼ of N. E. ¼ sec. 36, T. 65–7; t a much smaller island just east of it and also one north 16th An. Rep., p. 102.

No. 1428, (98);—Dark siliceous slate, from the E. ½ of sec. 28, T. 65–7; Knife lake. This slate varies from gra black; the specimens collected are gray, as this colore made up most of the point. 16th An. Rep., p. 109.

No. 1436, (99);—Micaceo-syenitic gneiss, from Opinin Basswood lake. This island is in sec. 10 (probably N. E. W. ¼), T. 64–10. 16th An. Rep., p. 110.

Twenty-five specimens of the *conglomeritic syenite* from naga lake were also collected. The writer numbered these 6 67 shows the syenite. This rock is described by Dr. Alex. Wi in the 16th An. Rep., pp. 219–222, and p. 334; also in the A can Geologist, vol. III, No. 3, p. 153.

V. BAROMETRICAL ELEVATIONS.

On the trip from Gunflint lake south to Brulé lake and to Ogishke-Muncie lake the elevation of each lake was from readings of an aneroid barometer. The following gives the elevation of each lake above lake Superior and above the sea level. The elevation of Gunflint lake (the st ing point) above lake Superior,—1,052 feet,—is taken from 9th An. Rep., p. 81. The highest water noted is Lost lake w is 1,427 feet above lake Superior, or 2,029 feet above the sea.

	Feet above lake Superior.	Feet a the
Gunflint lake	1052	1
Loon lake (195 ft. above Gunflint lake)	1247	1
Mayhew lake (110 feet above Loon lake)	1357	1
Iron lake (same hight as Mayhew lake)	1357	1
Portage lake (25 ft. above Iron lake)	1382	19
Poplar lake (20 ft. below Portage lake)	1362	19
Straight lake (25 ft. below Poplar lake)	1337	193
Caribou lake (10 ft. below Straight lake)	1327	192
Meed's lake (10 ft. above Caribou lake)	1337	193
North Brulé lake (20 ft. below Caribou lake)	1307	190
Stray lake (30 ft above North Brulé lake)	1337	193
Gaskanas lake (15 ft. above Stray lake)	1352	1954
Winchell lake (30 ft. above Gaskanas lake)	1382	1984
Sham lake (15 ft. above Winchell lake)	1397	1999

	Feet above lake Superior.	Feet above the sea.
ove Sham lake),	1427	2029
elow Lost lake),	1352	1954
below Brulé lake),	1346	1948
t. above lake Georgia),	1347	1949
ight as Surveyor's lake),	1347	1949
ft. below Found lake),	1317	1919
below lake Ida Belle),	1302	1904
ft. below Narrow lake),	1277	1879
elow Kiskadinna lake),	1217	1819
above Round lake),	1252	1854
bove Draper lake),	1292	1894
ight as lake No. 1),	1292	1894
bove lake No. 2),	1307	1909
bove lake No. 3),	1347	1949
ight as lake No. 4),	1347	1949
elow lake No. 5),	1322	1944
30 ft. below lake No. 6),	1292	1894
below Flying Cloud lake),	1227	1829
ft. below Kakego lake),	1167	1769
(20 ft. below Clothes Pin lake).	1147	1749
below Gabemichigama lake),	1144	1746
w Agamok lake),	1114	1716
e (60 ft. below Fox lake),	1054	*1656
	1102	‡1704
ove Wilder lake),	1106	1708

UE OF ROCK SAMPLES TO ILLUSTRATE THE OTES; COLLECTED BY ULY. S. GRANT DURING OF 1888.

rock samples are of museum size; and in many one specimen was collected, to represent a cer- his is especially true of the iron ores, of each of eces were taken for analysis. The samples have n the rooms of the survey. They are numbered , inclusive; the figures are green,—paris green lved in alcohol being used; after each number laced.

inclusive, were placed on an island which was n by a fire, and all the labels destroyed and the lored. These specimens have not been pre-

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9th An. Rep., p. 84, Ogishke-Muncie lake is 1,611 ft. above the sea; and . 384, it is 1,707 ft. above the sea.

4.

1. Magnetic iron slate and jasper, N. ½ of sec. 33, T. 66–6; Ottertrack lake; 80 rods south of the lake shore. P. 151.

2. Same as No. 1. P. 151.

3. Magnetic iron slate and jasper, N. E. ¼ of N. W. ¼ sec. 27, T. 66–6 (if the U. S. sections were extended northward); north shore of Ottertrack lake. P. 151.

4. Graywacke-like rock north shore of Ottertrack lake. just west of No. 3. P. 151.

5. Graywacke-like rock, north shore of Ottertrack lake, just east of No. 3. P. 151.

6. Coarse syenite, small island in the S. E. ¼ of S. E. ¼ sec. 13, T. 65–4; Gunflint lake. P. 152.

7. Hornblende schist in syenite; same locality. P. 152.

8. Sericitic schist, at the shore near the east end of the long bay on the north side of Gunflint lake. Same as No. 1278 (N. H. W.). P. 199.

8A. Same as No. 8, but apparently more siliceous. P. 199.

9. Gray gneissic rock, almost porphyrel; north shore of the long bay on the north side of Gunflint lake. Same as No. 1282 (N. H. W.). P 199.

10. Porphyrel, on the shore about three-fourths of a mile west of the east end of the long bay on the north side of Gunflint lake. Same as No. 1283 (N. H. W.). P. 199.

11. Sericitic schist, north shore of Gunflint lake; section I. P. 152.

12. Earthy schist, north of Gunflint lake; section I. P. 153.

13. Fine porphyrelloid rock, north of Gunflint lake; section I. P. 153.

14. A coarser condition of 13, north of Gunflint lake; section I. P 153.

15. A finer condition of 13, north of Gunflint lake; section I. P. 153.

16. Black slate, north of Gunflint lake; section I. P 153.

17. Trap rock, north of Gunflint lake; section I. P 153.

18. Fine trap from outer edge of dike, north of Gunflint lake; section I. P 153.

19. Trap from centre of same dike, north of Gunflint lake; section I. P 153.

20. Sericitic schist, north of Gunflint lake; section I. P 153.

21. Black slate, north of Gunflint lake; section I. P 153.

22. Fine gabbro, north of Gunflint lake; section I. P. 153.

23. Black slate, north of Gunflint lake; section I. P. 153.

. Porphyrel, north of Gunflint lake; section I. P. 154.
. Gray, somewhat micaceous schist; north of Gunflint lake;
on I. P. 154.
. Hornblende schist, north of Gunflint lake; section I. P.

. Hornblende schist, north of Gunflint lake; section I. P.

. Mica-schist, north of Gunflint lake; section I. P. 154.
. Feldspathic schist, north of Gunflint lake; section I. P.

. Hornblende schist, north of Gunflint lake; section I. P.

. Hornblende schist, north of Gunflint lake; section I. P.

. Mica-schist, north of Gunflint lake; section I. P. 154.
. Hornblende schist, north of Gunflint lake; section I. P.

. Syenitic gneiss, north of Gunflint lake; section II. P. 155.
. Hornblende schist inclosed in gneiss, north of Gunflint
; section II. P. 156.
. Trap from dike in gneiss, north of Gunflint lake; section
P. 156.
. Magnetitic portion of this dike, north of Gunflint lake;
on II. P. 156.
. Gray earthy slate, north of Gunflint lake; section II.
57.
. Porphyrel, north of Gunflint lake; section II. P. 157.
. Schistose dike rock, north of Gunflint lake; section II.
57.
. Finer portion of No. 40, north of Gunflint lake; section
P. 157.
. Porphyrel inclosed in dike, north of Gunflint lake; sec-
II. P. 157.
. Purplish-gray, vitreous quartzyte (Pewabic quartzyte);
. ¼ of sec. 29, T. 65-4, Chub lake. Same as No. 1340 (N. H.
P. 199.
. Magnetic iron ore from the pit at Chub lake, N. E. ¼ of
29, T. 65-4. P. 160.
. Quartzyte core from drill; Chub lake, N. E. ¼ of sec. 29,
5-4. P. 160.
. Syenitic gneiss from the north side of Blackfly bay,
flint lake. Same as No. 1316 (N. H. W.). P. 199.

47. Gray, red-weathering schist, north shore of Gunfl lake; section III. P. 157.

48. Black flinty slate, north of Gunflint lake; section I P. 157.

49. Sericitic schist, north of Gunflint lake: section P. 157.

50. Gabbro, north of Gunflint lake; section III. P. 157.

51. Hornblende-feldspar schist, north of Gunflint lake: tion III. P. 158.

52. Hornblende schist, north of Gunflint lake; section P. 158

53. Mica-schist, north of Gunflint lake; section III. P.

54. Hornblende schist, north of Gunflint lake; section P. 158.

55. Very coarsely-crystalline hornblende schist, north Gunflint lake; section III. P. 158.

56. Same as 55, north of Gunflint lake; section III. P. 1

57. Reddish syenite, north of Gunflint lake; section III. 158.

58. Syenitic gneiss, north of Gunflint lake; section III. 158.

58A. Same as 58, but showing the gneissic structure bet north of Gunflint lake; section III. P. 158.

59. Syenitic gneiss, north of Gunflint lake; section III. 158.

60. Fine-grained trap, from the west side of the narrow Gunflint lake; S. E. ¼ of N. W. ¼ sec. 19, T. 65-3. Same as 1312 (N. H. W.). P. 199.

61. Diabase from dike in syenite, first falls of Gunflint ri north of Gunflint lake. Same as No. 1318 (N. H. W.). P.

61A. Fine condition of No. 61. P. 160.

62. Syenitic gneiss, first falls of Gunflint river north of G flint lake. P. 160.

63. A condition of No. 61. P. 161.

64. A condition of No. 61, showing pitted surface. P. 16

65. Hornblende schist in No. 62; first falls of Gunflint ri north of Gunflint lake. P. 161.

66. Conglomeritic syenite from Saganaga lake. P. 200.

67. Syenite, Saganaga lake. P. 200.

68. Black slate, mouth of Ogishke-Muncie creek, N. E. S. E. ¼ sec. 26, T. 65-6; Ogishke-Muncie lake. Same as 1074 (N. H. W.). P. 197.

A. Broken condition of No. 68. P. 197.

B. Portion of No. 68 included in No. 69. P. 197.

C. Showing conchoidal fracture of No. 68. P. 197.

. Coarse-jointed massive rock, apparently igneous, mouth gishke-Muncie creek. N. E. ¼ of S. E. ¼ sec. 26, T. 65–6; hke-Muncie lake. Same as No. 1073 (N. H. W.). P. 197.

. Doleryte, about a quarter of a mile southeast from the e of Ogishke-Muncie lake; N. E. ¼ of sec. 24, T. 65–6. Same o. 1068 (N. H. W.). P. 196.

. Calcite from veins in No. 70.

. "Marble" from east side of Ogishke-Muncie lake; N. E. sec. 24, T. 65–6. Same as No. 1371 (N. H. W.). P. 199.

. Softer and more schistose portion of No. 72. P. 199.

. Angular siliceous pieces in No 72. P. 199.

. Portion of No. 72 showing a soft greenish mineral.

. Gray quartzyte, S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; shke-Muncie lake. P. 161.

7. Black slate, S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-ncie lake. P. 161.

. Siliceous band in No. 76. P. 162.

. Transition rock from No. 78 to No. 82. P. 162.

. Transition rock from No. 78 to No. 82. P. 162.

. Transition rock from No. 78 to No. 82. P. 162.

. Rock composed mostly of calcareous or dolomitic mat-S. E. ¼ of N. E. ¼ sec. 24, T. 65–6; Ogishke-Muncie lake. 2.

Part of Ogishke-Muncie conglomerate; S. E. ¼ of N. E. ¼ 24, T. 65–6; Ogishke-Muncie lake. P. 162.

Matrix of Ogishke-Muncie conglomerate; from Camper's d, S. E. ¼ of S. W. ¼ sec. 23, T. 65–6; Ogishke-Muncie lake. as No. 744 (N. H. W.). P. 194.

Gneissic (syenitic?) rock, south shore of the little bay at utheast corner of Kekequabic lake; S. E. ¼ of S. W. ¼ sec. 64–7. Same as No. 1044 (N. H. W.). P. 196.

Gray porphyritic rock, from the point which has the cor-f secs. 29, 30, 31, and 32, T. 65–6; Kekequabic lake. Same 1094 (N. H. W.). P. 197.

Biotite gabbro, N. E. ¼ of S. E. ¼ sec. 4, T. 64–7; Keke-ic lake. Same as 1049 (N. H. W.). P. 196.

Gray earthy slate, N. E. ¼ of S. E. ¼ sec. 4, T. 64–7; Keke-ic lake. P. 196.

. Transition from the slate (No. 88) to the gabbro (No. 87). 96

90. Transition from the slate (No. 88) to the gabbro (No. 87). P. 196.

91. Fine-grained gabbro, from the top of the bluff from which No. 87 was taken; N. E. ¼ of S. E. ¼ sec. 4, T. 64-7; Kekequabic lake. Same as No. 1050 (N. H. W.). P. 196.

92. Chlorite schist, N. W. ¼ of N. E. ¼ sec. 36, T. 65-7; Kekequabic lake. Same as No. 1409 (N. H. W.). P. 168.

93. Reddish syenite, from an island in Kekequabic lake; S. E. ¼ of N. W. ¼ sec. 3, T. 64-7. Same as No. 1100 (N. H. W.). P. 197.

94. A condition of the green chlorite schist, from island in the S. W. ¼ of N. W. ¼ sec. 3, T. 64-7; Kekequabic lake. P. 197.

95. Feldspar porphyry, from an island just northeast of the last; S. W. ¼ of N. W. ¼ sec. 3, T. 64-7; Kekequabic lake. P. 198.

96. Conglomeritic chlorite schist, from the north shore of Kekequabic lake where it is crossed by the line between T. 65-6 and T. 65-7. Same as No. 1098 (N. H. W.). P. 197.

97. Hornblende porphyry, from the north shore of Kekequabic lake; N. E. ¼ of sec. 36, T. 65-7. Same as No. 1059 (N. H. W.). P. 196.

98. Gray siliceous slate, from Knife lake; E. ½ of N. E. ¼ sec. 28, T. 65-7. Same as No. 1428 (N. H. W.). P. 200.

99. Micaceo-syenitic gneiss, from Opinin island, Basswood lake; sec. 10, T. 64-10. Same as No. 1436 (N. H. W.). P. 200.

100. Felsitic schist, from the south end of the portage from Fall lake to Newton lake; S. W. ¼ of sec. 3, T. 63-11. Same as No. 1109 (N. H. W.). P. 198.

101. Fine grained, slightly micaceous, quartzose rock; south shore of Kawishiwi river; N. W. ¼ of N. W. ¼ sec. 27, T. 63-10. Same as No. 989 (N. H. W.). P. 195.

102. Gray, red-weathering, gneissic rock, from an island in the N. W. ¼ of N. W. ¼ sec. 27, T. 63-10; Kawishiwi river. Same as No. 991 (N. H. W.). P. 195.

103. Hornblendic band in No. 102. P. 195.

104. Hornblendic band in No. 102. P. 195.

105. Reddish chloritic rock, N. E. ¼ of N. W. ¼ sec. 27, T. 63-10; south shore of Kawishiwi river. P. 195.

106. Hornblendic gneiss, N. E. ¼ of sec. 27, T. 63-10; south shore of Kawishiwi river. P. 195.

107. Reddish chloritic syenite, N. E. ¼ of N. W. ¼ sec. 27, T.

·10; south shore of Kawishiwi river. Same as No. 994 (N. H.). P. 195.

08. Quartzose schist, grading into No. 105; same locality. P. i.

.09. Quartzose schist, with some biotite; same locality. P. 196.

.10. Chloritic schist in No. 105; same locality. P. 196.

.11. Fine syenite, from the "Palisades;" N. W. ¼ of S.W. ¼ . 4, T. 62–10. Same as No. 979 (N. H. W.). P. 195.

.12. Fine grayish syenite, a condition of No. 111; same local- . P. 195.

113. Fine reddish syenite, a condition of 111; same locality. 195.

114. Coarse gabbro, east side of Birch lake, N. W. ¼ of sec. , T. 61–11. Same as No. 954 (N. H. W.). P. 194.

115. Magnetitic quartzyte, S. W. ¼ of sec. 9, T. 60–12; south Birch lake. P. 163.

116. Magnetitic quartzyte, N. W. ¼ of sec. 10, T. 60–12; south Birch lake. P. 163.

117. Biotitic gabbro, S. W. ¼ of sec. 10, T. 60–12; south of rch lake. P. 162.

118. Same as No. 117, but showing dark bands. Same local- y. P. 162.

118A. Same as 118, but from a loose piece. P. 162.

119. Gabbro, N. ½ of sec. 15, T. 60–12; south of Birch lake. . 162.

120. Gabbro, N. E. ¼ of sec. 15, T. 60–12; south of Birch ke. P. 163.

121. Breccia of mica-schist cemented by granite, from the tle point in the N. E. ¼ of S. E. ¼ sec. 21, T. 61–12; Birch ce. Same as No. 958 (N. H. W.). P. 195.

122. Fine-grained gabbro, from the west side of the little bay the S. E. ¼ of S. W. ¼ sec. 24, T. 62–12; Birch lake. Same as . 1137 (N. H. W.). P. 198.

23. Fine-grained red syenite, from the S. W. ¼ of S. W. ¼ . 24, T. 61–12; just east of the line between secs. 23 and 24, 1 300 feet north from the shore of Birch lake. Same as No. (N. H. W.). P. 195.

24. Biotite hornblende schist, N. W. ¼ of S. E. ¼ sec. 12, T. -12; east side of White Iron lake. Same as No. 1134 (N. H.). P. 198.

125. Biotite hornblende schist. N. W. ¼ of S. E. ¼ sec. 12, T. -12; east side of White Iron lake; 70 yards west of No. 124. 198.

126. Granite cutting No. 125; same locality. P. 198.

127. Black hornblende gneiss, just south of the line between secs. 6 and 7, T. 62–11; east shore of White Iron lake. This specimen shows the contact between the syenite and hornblende gneiss. Same as No. 1132 (N. H. W.). P. 198.

128. Siliceous schist, from "Silver City:" N. E. ¼ of sec. 32, T. 63–11. Same as No. 950 (N. H. W.). P. 194.

129. Biotitic diabase (?) cut by intrusive syenite, N. W. ¼ of S. E. ¼ sec. 6, T. 62–11, White Iron lake. Same as No. 1128 (N. H. W.). P. 198.

130. Syenite cutting No. 129; same locality. Same as No. 1129 (N. H. W.). P. 198.

131. Syenite taken from a dike in No. 129; same locality. P. 198.

132. Gabbro, north side of the little bay in the S. W. ¼ of S. E. ¼ sec. 15, T. 63–9; Kawishiwi river. P. 163.

133. Magnetitic iron ore in the gabbro, S. E. ¼ of sec. 15, T. 63–9. P. 163.

134. Muscovado, S. E. ¼ of N. E. ¼ sec. 15, T. 63–9; 60 yards northwest of the quarter post between secs. 14 and 15. P. 163.

135. Magnetitic iron ore; same locality as No. 134. P. 163.

136. Gabbro, showing gneissic structure; N. W. ¼ of sec. 5, T. 61–9; hill on east bank of stream. P. 164.

137. Gabbro, showing banding in No. 138; S. W. ¼ of sec. 5, T. 61–9; hill on west bank of stream. P. 165.

138. Gabbro, from same locality as No. 137. P. 165.

139. Red syenitic gneiss; S. ½ of sec. 32, T. 63–10; from a small island near the southern shore of the lake. P. 165.

140. Red syenite; S. ½ of sec. 32, T. 63–10; from a small island just north of the island where No. 139 was found. P. 165.

141. Syenite, with large crystals of hornblende; west side of the little bay in the N. W. ¼ of N. W. ¼ sec. 32, T. 63–10. P. 165.

142. Light gray gneiss; at the portage in the N. E. ¼ of N. W. ¼ sec. 31, T. 63–10. P. 165.

143. Hornblende schist(?) in No. 142; same locality. P. 165.

144. Dark hornblende rock, from the southern shore of the lake; S. ½ of sec. 32, T. 63–10. P. 166.

145. Transition from No. 144 to the syenite like No. 140; same locality as No. 144. P. 166.

146. To illustrate the same transition as No. 145; same locality. P. 166.

147. Coarse gabbro; west side of the little bay in the S. W. ¼
N. W. ¼ sec. 35, T. 62–8; lake Isabelle. P. 166.

148. Granulyte vein in the gabbro; a few rods north of No.
7. P. 166.

149. Very coarse gabbro; from cliff on the west side of the
ger bay in the N. W. ¼ of sec. 35, T. 62–8; lake Isabelle. P. 166.

150. Trap rock, S. W. ¼ of N. E. ¼ sec. 35, T. 62–8; lake Isa-
lle. P. 166.

151. Coarser condition of No. 150; same locality. P. 166.

152. Coarser decayed condition of No. 150; same locality, but
few rods back from the shore. P. 166.

153. Coarser condition of No. 150; same locality as No. 152.
166.

154. Condition of No. 150, containing patches of biotite; on
e shore, a little north of No. 150. P. 166.

155. A decayed condition of No. 154; same locality. P. 166.

156. A coarser condition of No. 154 and No. 155; same local-
y. P. 166.

157. Same trap, near contact with the gabbro; N. ½ of N.
¼ sec. 35, T. 62-8, lake Isabelle; on the shore, a few steps
rth of No. 156. P. 167.

158. Fine diabase from dike, N. E. ¼ of N. E. ¼ sec. 35, T.
–8; lake Isabelle. P. 167.

159. Diabase from dike, S. W. ¼ of sec. 30, T. 62–7; lake
abelle. P. 167.

160. Finer diabase from edge of the same dike from which
o. 159 was taken. P. 167.

161. Fine diabase from dike, W. ½ of sec. 31, T. 62–7; lake
abelle. P. 167.

162. Very coarse gabbro, north shore of Bellissima lake;
obably from sec. 27, T. 61–7. P. 167.

163. Gray feldspathic rock, S. W. ¼ of sec. 21, T. 60–6; Pine
ke. P. 163.

163A. Portion of No. 163 showing dark siliceous fragment;
me locality as No. 163. P. 168.

163B. Transition from No. 163 to No. 164; same locality. P. 168.

164. Granulyte, S. W. ¼ of sec. 21, T. 60–6; Pine lake. P. 168.

164A. A darker and more siliceous condition of No. 164;
me locality. P. 168.

165. Fine trap, S. W. ¼ of sec. 21, T. 60–6; Pine lake. P. 168.

165A. No. 165 containing fragments of No. 164; same local-
y. P. 168.

165B. A condition of No. 155 A; same locality. P. 168.

166. Diabasic rock, N. W. ¼ of sec. 28, T. 60–6; Pine lake. P. 168.

167. Diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

168. Very fine diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

169. Very fine diabasic rock, west shore of Pine lake; T. 60–6. P. 168.

170. Micaceous schist, from the syenite; north of Gunflint lake. P. 158.

171. Hornblendic schist, from the syenite; north of Gunflint lake. P. 158.

172. Coarse hornblendic schist, from the syenite; north of Gunflint lake. P. 158.

173. Syenite holding hornblendic schist fragments; north of Gunflint lake. P. 159.

174. Synenitic gneiss, north of Gunflint lake. P. 159.

175. Gabbro, S. W. ¼ of S. E. ¼ sec. 36, T. 65–3; south shore of Mayhew lake. P. 169.

176. Lighter colored gabbro, from end of little point in the S. W. ¼ of S. E. ¼ sec. 36, T. 65–3; Mayhew lake. P. 169.

177. Magnetic iron ore in the gabbro; same locality as No. 176. P. 169.

178. Decayed gabbro; on the line between ranges 2 and 3, just south of Mayhew lake. P. 169.

179. Magnetic iron ore in the gabbro, from the point crossed by the line between secs. 31 and 32, T. 65–2; Iron lake. P. 170.

180. Magnetitic gabbro; same locality as No. 179. P. 170.

181. Fine muscovado-like rock, S. E. ¼ of N. W. ¼ sec. 4, T. 64–2; Portage lake. P. 170.

182. Gabbro, from the little point in the N. W. ¼ of N. E. ¼ of N. W. ¼ sec. 12, T. 64–2; Poplar lake. P. 171.

183. Very fine gabbro, a condition of No. 182; same locality. P. 171.

184. Light gray gabbro with the labradorite collected together in spots; S. E. ¼ of N. E. ¼ sec. 12, T. 64–2; Poplar lake. P. 171.

185. Gabbro, from hill a quarter of a mile north of Meeds' lake, and a little west of the centre of sec. 15, T. 64–2. P. 172.

186. Rough Animike slate, N. W. ¼ of N. E. ¼ sec. 14, T. 64–2; Meeds' lake. P. 172.

187. Gabbro, S. E. ¼ of S. E. ¼ sec. 29, T. 64–2; north shore of Winchell lake. P. 174.

Coarse gabbro, from the point crossed by the line
en secs. 31 and 32, T. 62–4; south shore of Winchell lake.
l.

Gabbro, from the bluff in the N. W. ¼ of N. W. ¼ sec. 31,
-2; south shore of Winchell lake. P. 174.

Gabbro holding some pinkish feldspar, 20 feet above
39. P. 174.

. Altered gabbro, reddish; ten feet above No. 190. P. 175.

, Very dark syenite, two feet above No. 191. P. 175.

. Very dark syenite, two feet above No. 191. P. 175.

Fine pinkish-gray syenite, just above No. 193. P. 175.

, Pinkish-gray syenite, just above No. 194. P. 175.

. Pinkish-gray syenite, from top of bluff; same locality.
5.

, Showing change from gabbro to syenite; same locality.
5.

. A condition of the gabbro, N. W. ¼ of N. W. ¼ sec. 31,
–2; Winchell lake, north end of portage to Sham lake.
5.

. Altered gabbro, S. W. ¼ of N. W. ¼ sec. 31, T. 64–2;
end of Sham lake, at the portage to Winchell lake. P. 176.

. Fine red syenite, S. W. ¼ of N. W. ¼ sec. 31, T. 64–2;
ide of Sham lake. P. 176.

. Altered gabbro (?), S. E. ¼ of S. E. ¼ sec. 36, T. 64–3;
the southwest corner of Sham lake. P. 176.

. Fine red syenite, S. E. ¼ of S. W. ¼ sec. 1, T. 63–3; west
f Lost lake. P. 176.

. Dark siliceous trap, S. E. ¼ of S. W. ¼ sec. 12, T. 63–3,
ide of bay; Brulé lake. P 177.

. A condition of the gabbro (?) a little south of No. 203.
7.

. Gray feldspar porphyry, from the point in the S. E. ¼
E. ¼ of N. W. ¼ sec. 13, T. 63–3; Brulé lake. P. 177.

. Dark feldspar porphry; same locality as No. 205. P. 177.

. Red quartz porphyry; a few yards south of the last. P.

A. A darker and more siliceous condition of No. 207,
the contact with No. 208; same locality. P. 178.

. Fine diabase, in contact with No. 207; same locality.
8.

. Diabase-like rock, inclined to be amygdaloidal; small
1 in the S. E. ¼ of S. E. ¼ sec. 18, T. 63–3; Brulé lake. P. 178.

210. Gabbro, S. W. ¼ of sec. 18, T. 63–3; lake Georgia, a short distance west of the portage from Brulé lake. P. 179.

211. Dark feldspar porphyry; lake Georgia, a short distance west of No. 210. P. 179.

212. Trap; near its contact with the gabbro (No. 213); N. E. ¼ of S. W. ¼ sec. 13, T. 63–4; north side of lake Georgia. P. 179.

212A. Coarser condition of No. 212, farther from the contact. P. 179.

213. Gabbro in contact with trap (No. 212); same locality. P. 179.

214. Fine red syenite, S. W. ¼ of sec. 12, T. 63–4; Surveyor's lake, on the portage going west to Found lake. P. 179.

215. Diabase, S. ½ of sec. 11, T. 63–4; hill on north shore of Found lake. P. 180.

216. Fine red syenite holding pieces of a darker rock; S. ½ of sec. 11, T. 63–4; north shore of Found lake. P. 180.

217. Gabbro, S. W. ¼ of N. E. ¼ sec. 11, T. 63–4; lake Ida Belle. P. 180.

218. Diabase, S. W. ¼ of N. W. ¼ sec. 11, T. 63–4,—just east of the line between secs. 10 and 11; lake Ida Belle. P. 180.

219. Fine diabase from dike in gabbro, little point in the S. E. ¼ of sec. 10, T. 63–4; lake Ida Belle. P. 180.

220. Gabbro cut by the above dike. P. 180.

221. Fine-grained rock resembling "muscovado;" N. W. ¼ of sec. 15, T. 63–4, near the line between secs. 10 and 15; southwest of lake Ida Belle. P. 181.

222. Large crystals of hornblende from vein in gabbro; southwest of lake Ida Belle, near the last locality. P. 181.

223. Gabbro rich in magnetite; southwest of lake Ida Belle, near the last locality. P. 181.

224. Magnetite from the gabbro; N. ½ of sec. 16, T. 63–4, near the line between secs. 9 and 16; southwest of lake Ida Belle. P. 181.

225. Fine red syenite, east side of entrance to the small bay in the N. W. ¼ of N. E. ¼ sec. 10, T. 63–4; lake Ida Belle. P. 181.

226. Diabase from dike in gabbro; same locality as No. 225. P. 181.

227. Gabbro; same locality. P. 181.

228. Fine red syenite underlying the gabbro; north side of small island in the N. E. ¼ of S. E. ¼ sec. 3, T. 63–4; lake Ida Belle. P. 182.

. Dark rock cut by veins of the following; hill in the E. ec. 3, T. 63–4; lake Ida Belle. P. 182.

. Fine red syenite from veins in No. 229; same locality. 2.

. Showing contact of Nos. 229 and 230. P. 182.

. Fine red syenite from vein in gabbro; S. E. ¼ of sec. 35, -4, lake Ida Belle; on the portage going north. P. 183.

. A decayed condition of the gabbro; S. E. ¼ of N. E. ¼ 26, T. 64–4; west shore near the north end of Narrow P. 183.

¼. Muscovado, N. E. ¼ sec. 33, T, 65–4; west shore of Dra- ke. P. 184.

. Fine gray syenite underlying the gabbro; probably in W. ¼ of sec. 29, T. 65–4; on the portage from lake No. 3 to No. 4. P. 184.

. Gabbro overlying No. 234; same locality. P. 184.

. Muscovado; same locality as No. 234. P. 185.

. Fine gabbro, probably in S. ½ of sec. 29, T. 65–4; from island in southern part of lake No. 4. P. 185.

. Magnetic iron ore from the quartzyte, S. E. ¼ of S. E. 25, T. 65–5; south shore of Flying Cloud lake, near its rn end. P. 185.

. Greenstone; same locality as No. 238. P. 185.

. Magnetic iron ore from the quartzyte; probably in the ¼ of S. E. ¼ sec. 26, T. 65–5. P. 186.

. Greenstone, 12 feet north of No. 240. P. 186.

. Magnetitic quartzyte, just south of No. 241. P. 186.

. Magnetitic quartzyte lying on No. 244; probably in the . ¼ of N. E. ¼ sec. 35, T. 65–5. P. 186.

. Greenstone underlying No. 243; same locality. P. 186.

. Fine gabbro, from the little point in the N. E. ¼ of N. ec. 14, T. 64–7; Shoo-fly lake. P. 186.

. Gabbro, west side of the small lake in the S. W. ¼ of 3, T. 64–7. P. 187.

. Decayed condition of No. 246; west shore, near the south f the small lake in the S. W. ¼ of sec. 13, T. 64–7. P. 187.

. Olivinitic iron ore, S. E. ¼ of S. W. ¼ sec. 14, T. 64–7; side of Fraser lake. P. 187.

. Coarse hornblende (?) rock; same locality. P. 187.

. Olivinitic iron ore in No. 249; same locality. P. 187.

. Magnetitic quartzyte in No. 249; same locality. P. 187.

. Olivinitic iron ore; same locality. P. 187.

253. Coarse hornblende(?) rock, not as much decayed 249; same locality. P. 187.

254. Muscovado; same locality. P. 187.

255. No. 249 containing considerable magnetite; same ity. P. 187.

256. Same as No. 255 and showing a piece of No. 254; locality. P. 187.

257. Muscovado from northern foot of the ridge; same ity. P. 188.

258. Magnetitic quartzyte; same locality. P. 188.

259. Magnetitic quartzyte showing banding; same lo P. 188.

260. Showing contact of the quartzyte and the horn rock (No. 249); same locality. P. 188.

261. Fine decayed gabbro, N. W. ¼ of N. E. ¼ sec. 64-7; north shore of Fraser lake. P. 188.

262. Olivintic iron ore; same locality. P. 188.

263. Magnetitic quartzyte; same locality. P. 188.

264. Magnetitic quartzyte, showing banding; same lo P. 188.

265. Band of magnetite from the quartzyte; same lo P. 188.

266. Muscovado-like rock, from a bed in the quartzyt locality. P. 188.

267. Olivinitic iron ore; same locality. P. 189.

268. Large crystals, apparently similar to No. 249, bu taining much magnetite; same locality. P. 188.

269. Gabbro, N. E. ¼ of sec. 28, T. 64-7; a quarter of north of Thomas lake. P. 189.

270. Muscovado holding irregular blotches of a light feldspar; W. ½ of sec. 27, T. 64-7; north shore of Thoma P. 189.

271. Hornblende (?) rock similar to Nos. 249 and 253. of sec. 29, T. 64-7; north shore of Thomas lake. P. 189.

272. Magnetitic quartzyte showing banding on weather face; same locality. P. 189.

273. Iron ore, apparently almost pure magnetite; same ity. P. 189.

274. Magnetitic quartzyte; same locality. P. 190.

275. Same as No. 274. P. 190.

[illegible] **Pink** gabbro holding small quantities of what ap [illegible] oxide of iron; east side of the long bay in sec. [illegible] Alice. P. 191.

Gabbro, S. E. ¼ of N. W. ¼ sec. 15, T. 63–7; east shore of
lice. P. 191.

Green chloritic schist; north of Cady house, Tower.
as No. 868 (N. H. W.). P. 194.

Rough, scarcely banded jasper; 25 feet below the sur-
Stone mine, Tower. Same as No. 892 (N. H. W.). P. 194.

Red jasper with darker bands of iron ore; Stone mine,
. Same as No. 903 (N. H. W.). P. 194.

Matrix of conglomerate occurring north of the Cady
, Tower. Same as No. 908 (N. H. W.). P. 194.

Breccia, now converted to hematite and a floury white
al; Breitung mine, Tower. Same as No. 916 (N. H. W.).

Black or purplish-black clay slate; south shore of Pine
, Vermilion lake; a few feet east of the line between
15 and 16. Same as No. 921 (N. H. W.). P. 194.

Sericitic schist, rather siliceous; north shore of Pine
, Vermilion lake; on the line between ranges 15 and 16.

Sericitic schist; Pine island. P. 192.

Green, somewhat sericitic schist; Pine island. P. 192.

Green, somewhat graywacke-like rock; Pine island. P.

Rough sericitic schist; Pine island. P. 192.

Green, somewhat chloritic (?) schist; Pine island. P. 192.

Light gray argillaceous slate; Pine island. P. 192.

Coarser and rather sericitic condition of No. 290; Pine
. P. 192.

Coarser and rather sericitic condition of No. 290; Pine
. P. 192.

Coarser and rather sericitic condition of No. 290; Pine
. P. 192.

Light gray argillaceous slate; Pine island. P. 192.

Gray argillaceous slate; Pine island. P. 192.

A more siliceous condition of the slate; Pine island. P.

Gray argillaceous slate; Pine island. P. 192.

Argillaceous slate showing both the gray and black
; south shore of Pine island, on the line between ranges 15
. P. 192.

V.

MUSEUM ADDITIONS.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887-88.

Serial No.	Obtained. When	Obtained. Whence.	Name.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
6191	Jan., 1886	Geol. Survey	Gravel, largely limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, [illegible] feet.
6192	Jan., 1886	Geol. Survey	Sand and gravel	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 95 feet.
6193	Jan., 1886	Geol. Survey	Sand, mainly quartz	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 105 feet.
6194	Jan., 1886	Geol. Survey	Gravel and sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 112 feet.
6195	Jan., 1886	Geol. Survey	Sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 113 feet.
6196	Jan., 1886	Geol. Survey	Sand with magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 114 feet.
6197	Jan., 1886	Geol. Survey	Magnesian limestone and sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 116 feet.
6198	Jan., 1886	Geol. Survey	Magnesian limestone and sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 115 feet.
6199	Jan., 1886	Geol. Survey	Sand with some limestone	Indef.	Albert Lea, Minn.	[illegible]	From Mayor A. C. Wedge, 130 feet.
6200	Jan., 1886	Geol. Survey	Magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 133 feet.
6201	Jan., 1886	Geol. Survey	Light gray shale	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 135 feet.
6202	Jan., 1886	Geol. Survey	Light gray shale	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 160 feet.
6203	Jan., 1886	Geol. Survey	Battered films of metallic iron	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 165 feet.
6204	Jan., 1886	Geol. Survey	Gray shale, sandy	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 192 feet.
6205	Jan., 1886	Geol. Survey	Gray shale	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 210 feet.
6206	Jan., 1886	Geol. Survey	Gray shale	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 213 feet.
6207	Jan., 1886	Geol. Survey	Calcareous shale	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 220 feet.
6208	Jan., 1886	Geol. Survey	Compact, light colored limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 230 feet.
6209	Jan., 1886	Geol. Survey	Mainly magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 231 feet.
6210	Jan., 1886	Geol. Survey	Mainly white quartz sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 236 feet.
6211	Jan., 1886	Geol. Survey	Mainly white quartz sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 237 feet.
6212	Jan., 1886	Geol. Survey	Mainly white quartz sand	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 240 feet.
6213	Jan., 1886	Geol. Survey	Buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 241 feet.
6214	Jan., 1886	Geol. Survey	Buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 243 feet.
6215	Jan., 1886	Geol. Survey	Reddish buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 246 feet.
6216	Jan., 1889	Geol. Survey	Reddish buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 250 feet.
6217	Jan., 1886	Geol. Survey	Reddish buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 254 feet.
6218	Jan., 1886	Geol. Survey	Reddish buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 258 feet.
6219	Jan., 1886	Geol. Survey	Reddish-buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 260 feet.
6220	Jan., 1886	Geol. Survey	Reddish buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 265 feet.
6221	Jan., 1886	Geol. Survey	Reddish-buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 270 feet.
6222	Jan., 1886	Geol. Survey	Light gray, cryst. magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 275 feet.
6223	Jan., 1886	Geol. Survey	Buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 290 feet.
6224	Jan., 1886	Geol. Survey	Light buff magnesian limestone	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 295 feet.
6225	Jan., 1886	Geol. Survey	Vesicular, buff magnesian limestone.	Indef.	Albert Lea, Minn.		From Mayor A. C. Wedge, 300 feet.
6226	Oct., 1885	Geol. Survey	Drillings, mixed, mainly quartzose sand	Indef.	4 mi. S.E. of New Ulm.	Cret.	From C. M Phelps.
6227	Feb., 1888	Presented	Fibrous gypsum	2	Camillus, N. Y.		From N. H. Winchell.

6229	Feb., 1886	Presented	Gypsum	1	Sandusky, Ohio		From N. H. Winchell.	
6230	Feb., 1886	Presented	Gypsum	2	Ottawa Co., Ohio		From N. H. Winchell.	
6231	Feb., 1886	Presented	Fibrous gypsum	2	Grand Rapids, Mich		From N. H. Winchell.	
6232	Feb., 1886	Presented	Wollastonite	1	Rock Harbor, I. Royale		From N. H. Winchell.	
6233	Feb., 1886	Presented	Tufa	2	Marcellus Falls, N. Y.		From N. H. Winchell.	
6234	Feb., 1886	Presented	Calcite	7			From N. H. Winchell.	
6235	Feb., 1886	Presented	Chlorastrolites in rock	1	Rock Harbor, I. Royale		From N. H. Winchell.	
6236	Feb., 1886	Presented	Niagara limestone	1	Joliet, Ill		From N. H. Winchell.	
6237	Feb., 1886	Presented	Feldspathic quartzyte	1	Ann Arbor, Mich		From N. H. Winchell.	
6238	Feb., 1886	Presented	Aphanite	1	Ann Arbor, Mich		From N. H. Winchell.	
6239	Feb., 1886	Presented	Gneiss	1	Ann Arbor, Mich		From N. H. Winchell.	
6240	Feb., 1886	Presented	Gneiss	1	Ann Arbor, Mich		From N. H. Winchell.	
6241	Feb., 1886	Presented	Feldspathic quartzyte	1	Ann Arbor, Mich		From N. H. Winchell.	
6242	Feb., 1886	Presented	Mottled marble	1	Ann Arbor, Mich		From N. H. Winchell.	
6243	Feb., 1886	Presented	Buhr stone	1	Ohio		From N. H. Winchell.	
6244	Feb., 1886	Presented	Celestite	Indef	Pt. aux Peaux		From N. H. Winchell.	
6245	Feb., 1886	Presented	Drillings, sand, 20 feet.	Indef.	Gibbon, Sibley Co		From Andrew Erickson.	Under 275 ft. blue clay.
6246	Feb., 1886	Presented	Drillings, remains of wood, fr. No. 6245	Indef.	Gibbon, Sibley Co		From Andrew Erickson.	
6217	Feb., 1886	Presented	Drillings, red granite, 30 ft	Indef.	Gibbon, Sibley Co		From Andrew Erickson.	
6248	1878.	Geol. Survey.	Catlinite with glacial markings	1	Pipestone Co	Potsdam	From N. H. Winchell.	
6249	March, 1886	Presented	Silver ore (pulverized)	1	Newburyport, Mass		From G. R. Lumsden, Orig. No. 1.	
6250	March, 1886	Presented	Quartz crystals	Indef.	N. Stonington, Conn		From G. R. Lumsden, Orig. No. 2.	
6251	March, 1886	Presented	Sillmanite and zircon w. crys. of monosite	Indef.	Norwich Falls, Conn.		From G. R. Lumsden, Orig. No. 3.	
6252	March, 1886	Presented	Prehnite	1	Hartford, Conn		From G. R. Lumsden, Orig. No. 4.	
6253	March, 1886	Presented	Asbestos	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 5.	
6254	March, 1886	Presented	Amethyst	1	Nova Scotia		From G. R. Lumsden, Orig. No. 6.	
6255	March, 1886	Presented	Brucite and chondrodite.	1	Hoboken, N. J.		From G. R. Lumsden, Orig. No. 7.	
6256	March, 1886	Presented	Magnetic iron ore	1	New Jersey		From G. R. Lumsden, Orig. No. 8.	
6257	March, 1886	Presented	Micaceous iron ore	1	Africa		From G. R. Lumsden, Orig. No. 151.	
6258	March, 1886	Presented	Enstatite	1	Chester Co., Pa		From G. R. Lumsden, Orig. No. 11.	
6259	March, 1886	Presented	Moss Agate	1	Cupar, Scotland		From G. R. Lumsden, Orig. No. 12.	
6260	March, 1886	Presented	Prismatic talc mica	1	Greiner, Tyrol		From G. R. Lumsden, Orig. No. 18.	
6261	March, 1886	Presented	Iron mica	1	Löwenberg, Ger		From G. R. Lumsden, Orig. No. 20.	
6262	March, 1886	Presented	Rhomboidal graphite	1	Altstatt, Ger		From G. R. Lumsden, Orig No. 21.	
6263	March, 1886	Presented	Glassy actinolite.	1	Zoeptau, Ger		From G. R. Lumsden, Orig. No. 25.	
6264	March, 1886	Presented	Quartz crystals	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 26.	
6265	March, 1886	Presented	Basaltic hornblende	1	Schima, Bohemia		From G. R. Lumsden, Orig. No. 26.	
6266	March, 1886.	Presented	Selenite	3	Colorado		From G. R. Lumsden, Orig. No. 27.	
6267	March, 1886	Presented	Paraffin, from coal	1			From G. R. Lumsden, Orig. No. 30.	
6268	March, 1886	Presented	Tremolite	1	Tyrol		From G. R. Lumsden, Orig. No. 29.	
6269	March, 1886	Presented	Augite	7	Schima, Bohemia		From G. R. Lumsden, Orig. No. 31.	
6270	March, 1886	Presented	Schiller spar	1	Volpersdorf		From G. R. Lumsden, Orig. No. 32.	
6271	March, 1886	Presented	Plumbago	1	Preston Conn,		From G. R. Lumsden, Orig. No. 33.	
6272	March, 1886	Presented	Moss Agate	1	Sweet-water Co, Wyo		From G. R. Lumsden, Orig. No. 34.	
6273	March, 1886	Presented	Prismatic Topaz	Indef.	Schneckenstein, Ger		From G. R. Lumsden, Orig. No. 35.	
6274	March, 1886	Presented	Agate	1	Texas		From G. R. Lumsden, Orig. No. 36.	
6275	March, 1886	Presented	Zircon	1	Brewig, Norway		From G. R. Lumsden, Orig. No. 37.	

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887–88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimen	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6276	March, 1886..	Presented	Garnet sand	Indef	Roxbury, Mass		From G. R. Lumsden, Orig. No. 38.
6277	March, 1886..	Presented	Iolite	1	Origarfvi, Finland		From G. R. Lumsden, Orig. No. 39.
6278	March, 1886	Presented	Erlane (Breithauptite)	1	Schwarzenberg, Ger..		From G. R. Lumsden, Orig. No. 41.
6279	March, 1886 .	Presented	Galena	Indef	Dubuque, Iowa		From G. R. Lumsden, Orig. No. 42.
6280	March, 1886	Presented	Asbestos	1	Toronto, Canada		From G. R. Lumsden, Orig. No. 43.
6281	March, 1886..	Presented	Garnets	5	Haddam, Conn		From G. R. Lumsden, Orig. No. 44.
6282	March, 1886..	Presented	Green Feldspar	4	Rockport, Mass		From G. R. Lumsden, Orig. No. 50.
6283	March, 1886..	Presented	Lead Selenate	1	Durrenberg, Germ		From G. R. Lumsden, Orig. No. 51.
6284	March, 1886..	Presented	Mica	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 52.
6285	March, 1886..	Presented	Asbestos	1	Norwalk, Conn		From G. R. Lumsden, Orig. No. 53.
6286	March, 1886..	Presented	[illegible]	1	Greiner, Tyrol		From G. R. Lumsden, Orig. No. 54.
6287	March, 1886..	Presented	Asbestos	1	Vermon		From G. R. Lumsden, Orig. No. 55.
6288	March, 1886.	Presented	Sodalite	1	Eifel, Germ		From G. R. Lumsden, Orig. No. 56.
6289	March, 1886.	Presented	Hayanite	1	Laacher, Germ		From G. R. Lumsden, Orig. No. 57.
6290	March, 1886..	Presented	Epidote	2	Franconia, N. H		From G. R. Lumsden, Orig. No. 59.
6291	March, 1886..	Presented	Spodumene	1	Sterling, Mass		From G. R. Lumsden, Orig. No. 60.
6292	March, 1886..	Presented	Cobalt	3			From G. R. Lumsden, Orig. No. 62.
6293	March, 1886..	Presented	Chiastolite	1	Gefrees, Germ		From G. R. Lumsden, Orig. No. 63.
6294	March, 1886..	Presented	Porcelainyte	1	Toeplitz, Germ		From G. R. Lumsden, Orig. No. 65.
6295	March, 1886..	Presented	Asbestos	Indef	York Co., Pa		From G. R. Lumsden, Orig. No. 68.
6296	March, 1886..	Presented	Tripolyte	1	Bilin, Prussia		From G. R. Lumsden, Orig. No. 69.
6297	March, 1886..	Presented	Magnetite	1	Rhode Island		From G. R. Lumsden, Orig. No. 74.
6298	March, 1886..	Presented	Graphite	1	Ticonderoga, N. Y		From G. R. Lumsden, Orig. No. 76.
6299	March, 1886..	Presented	Stibnite	1	Halbermond		From G. R. Lumsden, Orig. No. 77.
6300	March, 1886..	Presented	Onyx	1	Oberstein, Germ		From G. R. Lumsden, Orig. No. 78.
6301	March, 1886..	Presented	Chloropal	Indef	Madura, India		From G. R. Lumsden, Orig. No. 79.
6302	March, 1886..	Presented	Calamine	1	Wiesloch		From G. R. Lumsden, Orig. No. 80.
6303	March, 1886..	Presented	Calamine	1	Raibel, Corinthia		From G. R. Lumsden, Orig. No. 82.
6304	March, 1886..	Presented	Black mica schist	1	Ames, N. Y		From G. R. Lumsden, Orig. No. 85.
6305	March, 1886..	Presented	Wolframite	1	Zirmwald, Bohemia		From G. R. Lumsden, Orig. No. 87.
6306	March, 1886..	Presented	Covellite	1	Pennsylvania		From G. R. Lumsden, Orig. No. 88.
6307	March, 1886..	Presented	Iron pyrites	1	Marienberg, Germ		From G. R. Lumsden, Orig. No. 93.
6308	March, 1886..	Presented	Hexahedral iron pyrites	1	Alsan, Germ		From G. R. Lumsden, Orig. No. 94.

							From G. R. Lumsden, Orig. No 111.
6317	March, 1886..	Presented..	Siderite	1	Germany		From G. R. Lumsden, Orig. No. 114.
6318	March, 1886..	Presented	Native sulphur	1	Sicily		From G. R. Lumsden, Orig. No. 115.
6319	March, 1886..	Presented	Red cobalt ochre	1	Schneeberg, Germ		From G R. Lumsden, Orig. No. 119.
6320	March, 1886..	Presented	Copper nickel	1	Schneeberg, Germ		From G. R. Lumsden, Orig. No. 121.
6321	March, 1886..	Presented	Variegated copper	1	Freiberg, Germ		From G. R. Lumsden, Orig. No. 125.
6322	March, 1886..	Presented	Copper pyrites	1	Siegen, Germ		From G. R. Lumsden, Orig. No. 126.
6323	March, 1886..	Presented	Copper pyrites	1	Alsan, Germ		From G. R. Lumsden, Orig. No. 127.
6324	March, 1886..	Presented	Gray copper	1	Thuringia		From G. R. Lumsden, Orig. No. 128.
6325	March, 1886..	Presented	Red oxyde of copper	1	Dillenberg, Nassau		From G. R. Lumsden, Orig. No. 131.
6326	March, 1886..	Presented	Malachite	1	Dillenberg, Nassau		From G. R. Lumsden, Orig. No. 132.
6327	March, 1886..	Presented	Blue copper	1	Rheinbreitenbach		From G. R. Lumsden, Orig. No. 133.
6328	March, 1886..	Presented	Iron slag	2	Norwich, Conn.		From G. R. Lumsden, Orig. No. 137.
6329	March, 1886..	Presented	Hepatic mercurial-ore	1	Iddria, Illyrien		From G. R. Lumsden, Orig. No. 138.
6330	March, 1886..	Presented	Argentite	1	Freiberg, Germ		From G. R. Lumsden, Orig. No. 140.
6331	March, 1886..	Presented	Williamsite	1	Rock Springs, Ind		From G. R. Lumsden, Orig. No. 142.
6332	March, 1886..	Presented	Nagyagite	1	Nagyag, Transsylva'a		From G. R. Lumsden, Orig. No. 143.
6333	March, 1886..	Presented	Native platina	Indef.	Tagelsk, Ural		From G. R. Lumsden, Orig. No. 144.
6334	March, 1886..	Presented	Silver pyrites	1	Mont. Co., N. Y.		From G. R. Lumsden, Orig. No. 145.
6335	March, 1886..	Presented	Blue iron earth	Indef.	Ebstorf		From G. R. Lumsden, Orig. No. 152.
6336	March, 1886..	Presented	Asbestos	Indef.	Canterbury, N. H		From G. R. Lumsden, Orig. No. 153.
6337	March, 1886..	Presented	Beryl	1	Canada		From G. R. Lumsden, Orig. No. 157.
6338	March, 1886..	Presented	Mica	1	New Jersey		From G. R. Lumsden, Orig. No. 158.
6339	March, 1886..	Presented	Brown chalcedony	1	Madura, India		From G. R. Lumsden, Orig. No. 159.
6340	March, 1886..	Presented	Brown coal	1	Bruhl, Germ		From G. R. Lumsden, Orig. No. 160.
6341	March, 1886..	Presented	Peat	1	Kloster Laach		From G. R. Lumsden, Orig. No. 162.
6342	March, 1886..	Presented	Native boracic acid	Indef.	Vulkano		From G. R. Lumsden, Orig. No. 163.
6343	March, 1886..	Presented	Hayesine	Indef.	Iquique, Peru		From G. R. Lumsden, Orig. No. 165.
6344	March, 1886..	Presented	Brown coal	1	Frierdorf, Bonn		From G. R. Lumsden, Orig. No. 172.
6345	March, 1886..	Presented	Nitratine	Indef.	Chili		From G. R. Lumsden, Orig. No. 176.
6346	March, 1886..	Presented	Celestite	Indef.	Dornburg, Jena		From G. R. Lumsden, Orig. No. 179.
6347	March, 1886..	Presented	Garnet	1	New Hampshire		From G. R. Lumsden, Orig. No. 180.
6348	March, 1886..	Presented	Crystals of hematite	1	New York		From G. R. Lumsden, Orig. No. 183.
6349	March, 1886..	Presented	Emery	1	Naxos (Grecian Isl.)		From G. R. Lumsden, Orig. No. 186.
6350	March, 1886..	Presented	Asbestos	Indef.	Greiner, Tyrol		From G. R. Lumsden, Orig. No. 189.
6351	March, 1886..	Presented	Calcite	1	Howe's cave, N. Y		From G. R. Lumsden, Orig. No. 192.
6352	March, 1886..	Presented	Native lodestone	1	Mt. Calamite, Elba		From G. R. Lumsden, Orig. No. 195.
6353	March, 1886..	Presented	Rutile	5	Freiberg, Germ		From G. R. Lumsden, Orig. No. 195 A.
6354	March, 1886..	Presented	Corundum (ruby)	Indef.	Capelan Mts		From G. R. Lumsden, Orig. No. 196.
6355	March, 1886..	Presented	Corundum (sapphire)	1	Miark, Germ		From G. R. Lumsden, Orig. No. 197.
6356	March, 1886..	Presented	Spinel (blue)	1	Sweden		From G. R. Lumsden, Orig. No. 199.
6357	March, 1886..	Presented	Spinel (ruby)	Indef.	Candy, Ceylon Isl.		From G. R. Lumsden, Orig. No. 200.
6358	March, 1886..	Presented	Tremolite	1	New York		From G. R. Lumsden, Orig. No. 202.
6359	March, 1886..	Presented	Beryl	1	Haddam, Conn		From G. R. Lumsden, Orig. No. 204.
6360	March, 1886..	Presented	Smoky quartz	1	N. Benton, N. H		From G. R. Lumsden, Orig. No. 208.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887–88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6361	March, 1886..	Presented	Tourmaline (red)	1	Moravia		From G. R. Lumsden, Orig. No. 209.
6362	March, 1886...	Presented	Smoky quartz	3	St. Gothard		From G. R. Lumsden, Orig. No. 212.
6363	March, 1886...	Presented	Amethyst	1	Oberstein		From G. R. Lumsden, Orig. No. 213.
6364	March, 1886...	Presented	Cat's-eye	1	Hoff in Bavaria		From G. R. Lumsden, Orig. No. 214.
6365	March, 1886...	Presented	Pyrolusite	1	New York		From G. R. Lumsden, Orig. No. 216.
6366	March, 1886...	Presented	Carnelian	1	Oberstein		From G. R. Lumsden, Orig. No. 219.
6367	March, 1886...	Presented	Andalusite	2	Lancaster, N. H		From G. R. Lumsden, Orig. No. 223.
6368	March, 1886...	Presented	Jasper (globular)	1	Kandem, Baden		From G. R. Lumsden, Orig. No. 224.
6369	March, 1886...	Presented	Muscovite	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 226.
6370	March, 1886...	Presented	Bog iron ore	1	Ft. Plain, N. Y.		From G. R. Lumsden, Orig. No. 228.
6371	March, 1886...	Presented	Foliated brown coal	1	Ratt, Germany		From G. R. Lumsden, Orig. No. 229.
6372	March, 1886...	Presented	Fire opal	Indef.	Zamapan		From G. R. Lumsden, Orig. No. 231.
6373	March, 1886...	Presented	Chrysolite	1	Dreis in d. Eifel		From G. R. Lumsden, Orig. No. 232.
6374	March, 1886...	Presented	Serpentine	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 233.
6375	March, 1886...	Presented	Diopside	3	Rothenkopf, Tyrol		From G. R. Lumsden, Orig. No. 235.
6376	March, 1886..	Presented	Bastite	1	Baste in Hartz		From G. R. Lumsden, Orig. No. 236.
6377	March, 1886...	Presented	Andularia feldspar	1	Mt. Stella, St. Goth'd		From G. R. Lumsden, Orig. No. 237.
6378	March, 1886...	Presented	Actinolite	1	Connecticut		From G. R. Lumsden, Orig. No. 238.
6379	March, 1886...	Presented	Agate with stilbite in cavity	1	Partridge Isl., N. S.		From G. R. Lumsden, Orig. No. 240.
6380	March, 1886...	Presented	Lazulite	1	Krieglach, Styria		From G. R. Lumsden, Orig. No. 241.
6381	March, 1886...	Presented	Turquois	Indef.	Khorassan, Persia		From G. R. Lumsden, Orig. No. 242.
6382	March, 1886...	Presented	Fluorite	1	Freiberg, Germany		From G. R. Lumsden, Orig. No. 243.
6383	March, 1886...	Presented	Vesuvianite	1	Monzoni, Tyrol		From G. R. Lumsden, Orig No. 246.
6384	March, 1886...	Presented	Pyrope	Indef.	Meronitz, Bohemia		From G. R. Lumsden, Orig. No. 249.
6385	March, 1886...	Presented	Amber	2	Prussia		From G. R. Lumsden, Orig. No. 254.
6386	March, 1886...	Presented	Pyrites and lead	1	Mont. County, N. Y.		From G. R. Lumsden, Orig. No. 257.
6387	March, 1886...	Presented	Galena	1	Pennsylvania		From G. R. Lumsden, Orig. No. 263.
6388	March, 1886...	Presented	Gold bearing quartz	1	Mariposa		From G. R. Lumsden, Orig. No. 269.
6389	March, 1886...	Presented	Hornstone	1	Vermont		From G. R. Lumsden, Orig. No. 272.
6390	March, 1886...	Presented	Beryl	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 277.
6391	March, 1886...	Presented	Limestone crystals	1	Kentucky		From G. R. Lumsden, Orig. No. 279.
6392	March, 1886...	Presented	Muscovite	1	Connecticut		From G. R. Lumsden, Orig. No. 281.
6393	March, 1886...	Presented	Iron pyrites	1	Pennsylvania		From G. R. Lumsden, Orig. No. 288.
6394	March, 1886...	Presented	Galena	1	Rossie, N. Y.		From G. R. Lumsden, Orig. No. 295.
6395	March, 1886...	Presented	Stilbite	1	Sandy Cove, N. S.		From G. R. Lumsden, Orig. No. 297.
6396	March, 1886...	Presented	Sand (for making glass)	Indef.	Mystic, Conn		From G. R. Lumsden, Orig. No. 299.
6397	March, 1886...	Presented	Asbestos	Indef.	Canada		From G. R. Lumsden, Orig. No. 300.

6405	March, 1886..	Presented	Clay, pebbles and pyrites	Indef.	Lake Michigan		From G. R. Lumsden, Orig. No. 312.
6406	March, 1886..	Presented	Kaolin	Indef.	Saxony, Germany		From G. R. Lumsden, Orig. No. 318.
6407	March, 1886..	Presented	Moon-stone	Indef.	Haddam, Conn		From G. R. Lumsden, Orig. No. 318.
6408	March, 1886..	Presented	Garnets	Indef.	Willimantic, Conn		From G. R. Lumsden, Orig. No. 338.
6409	March, 1886..	Presented	Garnets	1	New Haven, Conn		From G. R. Lumsden, Orig. No. 340
6410	March, 1886..	Presented	Piece of stalagmite	1	Howe's Cave, N. Y		From G. R. Lumsden, Orig. No. 350.
6411	March, 1886..	Presented	Foliated sulphate of lime	1	Connecticut		From G. R. Lumsden, Orig. No. 370.
6412	March, 1886..	Presented	Asbestos	1	Norwalk, Conn		From G. R. Lumsden, Orig. No. 380.
6413	March, 1886..	Presented	Rose quartz	1	New Britain, Conn		From G. R. Lumsden, Orig. No. 410.
6414	March, 1886..	Presented	Chrysoberyl	7	Haddam, Conn		From G. R. Lumsden, Orig. No. 414.
6415	March, 1886..	Presented	Feldspar	1	Fort Plain, N. Y		From G. R. Lumsden, Orig. No. 415.
6416	March, 1886..	Presented	Volcanic glass	Indef.	Crater of Owhyhee		From G. R. Lumsden, Orig. No. 490.
6417	March, 1886..	Presented	Beryl (emerald)	Indef.	East Siberia		From G. R. Lumsden, Orig. No. 500.
6418	March, 1886..	Presented	Glassy feldspar	1	Drachenfels, Germ		From G. R. Lumsden, Orig. No. 3.
6419	March, 1886..	Presented	Gypsum	2			From G. R. Lumsden, Orig. No. 19.
6420	March, 1886..	Presented	Iron pyrites	2			From G. R. Lumsden, Orig. No. 22.
6421	March, 1886..	Presented	Chalco-pyrite, galena and calcite	3			From G. R. Lumsden, Orig. No. 71.
6422	March, 1886..	Presented	Siderite	1			From G. R. Lumsden, Orig. No. 91.
6423	March, 1886..	Presented	Wood opal	1			From G. R. Lumsden, Orig. No. 109.
6424	March, 1886..	Presented	Malachite (earthy)	Indef.			From G. R. Lumsden, Orig. No. 274.
6225	March, 1886..	Presented	Tremolite	1			From G. R. Lumsden, Orig. No. 289.
6226	March, 1886..	Presented	Black limestone	1			From G. R. Lumsden, Orig. No. 307.
6427	March, 1886..	Presented	Agate (polished)	1			From G. R. Lumsden, Orig. No. 390.
6428	March, 1886..	Presented	Beryl	5			From G. R. Lumsden, Orig. No. 460.
6429	March, 1886..	Presented	Wood jasper.	1			From G. R. Lumsden, Orig. No. 470.
6430	March, 1886..	Presented	Petrified wood	1			From G. R. Lumsden.
6431	March, 1886..	Presented	Concretions	4	Ill ?		From G. R. Lumsden.
6432	Jan., 1886	Presented	Ostrea bellaplicata	10	Sherman, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6433	Jan., 1886	Presented	Ostrea quadriplicata	10	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6434	Jan., 1886	Presented	Ostrea quadriplicata (or allied species)	5	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6435	Jan., 1886	Presented	Ostrea carinata	5	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6436	Jan., 1886	Presented	Gryphæa pitcheri	20	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6437	Jan., 1886	Presented	Gryphæa pitcheri variety	5	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6438	Jan., 1886	Presented	Gryphæa pitcheri variety	5	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6439	Jan., 1886	Presented	Exogyra ariatenum	15	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6440	Jan., 1886	Presented	Exogyra matheroniana	3	Ft. Worth, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6441	Jan., 1886	Presented	Cordium	1	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6442	Jan., 1886	Presented	Corbula graysonensis	2	Sherman, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6443	Jan., 1886	Presented	Lima wacoensis	1	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6444	Jan., 1886	Presented	Neitha texana	3	Denison, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.
6445	Jan., 1886	Presented	Terebratula wacoensis.	15	Ft. Worth, Texas	Cretaceous	From F. A. Sampson, Sedalia, Mo.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887-88. (*Continued.*)

Serial No.	Obtained. When.	Obtained. Whence.	Name.	No. of specimens.	Locality.	Formation.	Collector and Remarks.
6446	Jan., 1886	Presented	Serpula communis	1	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo
6447	Jan., 1886	Presented	Serpula communis	1	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo
6448	Jan., 1886	Presented	Holaster elegans	2	Denison, Tex	Cretaceous	From F. A. Sampson, Sedalia, Mo
6451	Jan., 1886	Presented	Chonophyllum sedaliensis, White	4	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo
6452	Jan., 1886	Presented	Michelina expansa, White	1	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo
6453	Jan., 1886	Presented	Michelina placenta, White	2	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo
6454	Jan., 1886	Presented	Zaphrentis calceola, W. & W	10	Sedalia, Mo		From F. A. Sampson, Sedalia, Mo
6455	Jan., 1886	Presented	Flabellum wailesii, Conr	10	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6456	Jan., 1886	Presented	Turbinola machurii	2	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6457	Jan., 1886	Presented	Osteodes	5	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6458	Jan., 1886	Presented	Cellopora	6	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6459	Jan., 1886	Presented	Cellopora informata, Lonsd	3	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6460	Jan., 1886	Presented	Heteropora tortilis	5	Jackson, Miss	Tertiary	From F. A. Sampson, Sedalia, Mo
6461	March, 1886	Exchange	Diabase	1	Near Leesburg, Va		Smithsonian Inst., Washington, D. C.
6462	March, 1886	Exchange	Diabase	1	Addison, Maine		Smith. Inst., Wash., Orig. No. [illegible]
6463	March, 1886	Exchange	Diabase	1	York, Pa		Smith. Inst., Wash., Orig. No. [illegible]
6464	March, 1886	Exchange	Diabase	1	Somerville, Mass.		Smith. Inst., Wash., Orig. No. [illegible]
6465	March, 1886	Exchange	Olivine diabase	1	Lewiston, Maine.		Smith. Inst., Wash., Orig. No. [illegible]
6466	March, 1886	Exchange	Norite	1	Nahant, Mass		Smith. Inst., Wash., Orig. No. [illegible]
6467	March, 1886	Exchange	Melaphyr	1	Brighton, Mass		Smith. Inst., Wash., Orig. No. [illegible]
6468	March, 1886	Exchange	Melaphyr	1	Brighton, Mass.		Smith. Inst., Wash., Orig. No. [illegible]
6469	March, 1886	Exchange	Amphibolite	1	Chester, Mass		Smith. Inst., Wash., Orig. No. [illegible]
6470	March, 1886	Exchange	Hypersthene andesite	1	Mt. Shasta, Calif		Smith. Inst., Wash., Orig. No. [illegible]
6471	March, 1886	Exchange	Hornblende andesite	1	Mt. Shasta, Calif		Smith. Inst., Wash., Orig. No. [illegible]
6472	March, 1886	Exchange	Hornblende andesite	1	Mexico, Mexico		Smith. Inst., Wash., Orig. No. [illegible]
6473	March, 1886	Exchange	Elæolite syenite	1	N'r Deckertown, N. J		Smith. Inst., Wash., D. C.
6474	March, 1886	Exchange	Elæolite syenite	1	S. Litchfield, Maine		Smith. Inst., Wash., Orig. No. [illegible]
6475	March, 1886	Exchange	Rhyolite	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. [illegible]
6476	March, 1886	Exchange	Rhyolite	1	Zacatecas, Mexico		Smith. Inst., Wash., D. C.
6477	March, 1886	Exchange	Rhyolite tuff	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. [illegible]
6478	March, 1886	Exchange	Rhyolite tuff	1	Douglass Co, Colorado		Smith. Inst., Wash., Orig. No. [illegible]
6479	March, 1886	Exchange	Rhyolite tuff	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. [illegible]
6480	March, 1886	Exchange	Basalt	1	Coast of Ireland		Smith. Inst., Wash., Orig. No. [illegible]
6481	March, 1886	Exchange	Basalt	1	Zacatecas, Mexico		Smith. Inst., Wash., Orig. No. [illegible]
6482	March, 1886	Exchange	Leucite basalt	1	Vesuvius, flow of 1872		Smith. Inst., Wash., Orig. No. [illegible]
6483	March, 1886	Exchange	Obsidian	1	Mono Craters, Calif		Smith. Inst., Wash., Orig. No. [illegible]
6484	March, 1886	Exchange	Satin spar	1	Pueblo, Mexico		Smith. Inst., Wash., Orig. No. 47,810.

6494	May, 1886	Geol. Survey	Blue till	“ 3	Indef.	Tracy, Minn	Drillings of the Tracy deep well.	N. H. Winchell, No. ft. 100, depth 120
6495	May, 1886	Geol. Survey	Fine gravel, nearly black	“ 4	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 5, depth 125
6496	May, 1886	Geol. Survey	Fine blue clay	“ 5	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 20, depth 145
6497	May, 1886	Geol. Survey	Coarse gravel (similar to No. 4)	“ 6	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 20, depth 165
6498	May, 1886	Geol. Survey	Fine blue clay	“ 7	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 12, depth 177
6499	May, 1886	Geol. Survey	Fine sandstone, homogeneous	“ 8	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 20, depth 197
6500	May, 1886	Geol. Survey	Dark gray shale	“ 9	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 213, depth 410
6501	May, 1886	Geol. Survey	Fine light blue or greenish sand	“ 10	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 60, depth 470
6502	May, 1886	Geol. Survey	Blue clay	“ 11	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 43, depth 513
6503	May, 1886	Geol. Survey	Cretaceous grit	“ 12	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 32, depth 545
6504	May, 1886	Geol. Survey	Fine gray sandstone	“ 13	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 5, depth 550
6505	May, 1886	Geol. Survey	Blue clay like that of 6502	“ 14	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 30, depth 580
6506	May, 1886	Geol. Survey	Angular, rounded grains of sand	“ 15	Indef	Tracy, Minn		N. H. Winchell, No. ft. 7, depth 587
6507	May, 1886	Geol. Survey	Dark unctuous, fine clay	“ 16	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 24, depth 611
6508	May, 1886	Geol. Survey	White, kaolinic clay	“ 17	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 8, depth 619
6509	May, 1886	Geol. Survey	White and gray quartz sand	“ 18	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 8, depth 627
6510	May, 1886	Geol. Survey	Same, but w some kaolinic m't'r'l	“ 19	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 10, depth 637
6511	May, 1886	Geol. Survey	White kaolin, with blue clay	“ 20	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 25, depth 662
6512	May, 1886	Geol. Survey	White angular quartz sand	“ 21	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 2, depth 664
6513	May, 1886	Geol. Survey	Same as last	“ 22	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 2, depth 666
6514	May, 1886	Geol. Survey	Same, but finer	“ 23	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 6, depth 672
6515	May, 1886	Geol. Survey	White sand w some kaolinic mt'l	“ 24	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 18, depth 690
6516	May, 1886	Geol. Survey	Reddish orthoclastic granite	“ 25	Indef.	Tracy, Minn		N. H. Winchell, No. ft. 25, depth 715
6517	May, 1886	Geol. Survey	Drillings from Lakewood Cem't'ry well		Indef.	Minneapolis, Minn		N. H. Winchell, at 2118 ft.
6518	May, 1886	Presented	Trochus missouriensis (sw)		1	Kansas City, Mo	Coal meas.	From A. M. Light.
6520	Oct., 1886	A. F. Bechdolt	Fossil leaves		29	Nr source Rosebud riv, Mont		On Tongue river slope of the Wolf Mts.
6521	Oct., 1886	A. F. Bechdolt	Quercus Winchellii sp. nov			“ “		Orig. No. 1, 1a From 6520.
6522	Oct., 1886	A. F. Bechdolt	Hamamelites latifolius sp. nov.			“ “		Orig. No. 2, 3d, 4, 5, 11, 11a. 19, 20, 26. From 6520.
6523	Oct., 1886.	A. F. Bechdolt	Crataegus Wyomingiana, Lesq			“ “		Orig. No. 2a, 2b, 7, 7a, 7b, 7c, 7e, 9, 11b, 14, 15, 18, 19a, 22a, 27, 30, and 31. From 6520.
6524	Oct., 1886	A. F. Bechdolt	Artocarpidium intermedium sp. nov			“ “		Orig. No. 2c, 8. From 6520.
6525	Oct., 1886	A. F. Bechdolt	Ficus producta sp. nov			“ “		Orig No. 3, 3a, 3b, 3e, 7d, 11c. 11f, 11g. 13a, 14a, 19b, 21a, 22, 28, 29. From 6520.
6526	Oct., 1886	A. F. Bechdolt	Hamamelites latifolius and seed of [V'b'm.			“ “		Orig. No. 6, 6a. From 6520.
6527	Oct., 1886	A. F. Bechdolt	Quercus ettinghausii sp. nov			“ “		Orig. No. 10. From 6520.
6528	Oct., 1886	A. F. Bechdolt	Cornus forshammeri Heer			“ “		Orig. No. 12, 13. From 6520.
6529	Oct., 1886	A. F. Bechdolt	Ficus dura sp. nov			“ “		Orig. No. 16, 25. From 6520.
6530	Oct., 1886	A. F. Bechdolt	Diospyros, calix of fruit			“ “		Orig. No. 17. From 6520.
6531	Oct., 1886	A. F. Bechdolt	Viburnum heerii sp. nov			“ “		Orig. No. 21. From 6520.
6532	Oct., 1886	A. F. Bechdolt	Cornus? specis undeterminable			“ “		Orig. No. 23. From 6520.
6533	Oct., 1886	A. F. Bechdolt	Seed of Viburnum			“ “		Orig. No. 24. From 6520.
6534	Oct., 1886	A. F. Bechdolt	Apeiopsis grandifolia sp. nov			“ “		Orig. No. 32, 33. From 6520.
6535	Oct., 1886	A. F. Bechdolt	Seed of Viburnum? heerii? sp. nov			“ “		Orig. No. 34. From 6520.
6537	Sept., 1885	H. B. Griffin	Concretion		1	Long Lake, Hennepin Co	Cret.	Forty feet below surface. Presented.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887-88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimen.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6538	Sept., 1887	J. W. Bird	Wood	1	Martin Co., Minn	Drift	From a well 68 feet below surface.
6539	Sept., 1887	Hon. C. B. Little	Muscovite	1	Grafton, N. H		Presented.
6540	Sept., 1887	Rev.G.H.Trabert	Agate conglomerate	1	Duluth, Minn	Drift	Presented. From a boulder.
6541	Sept., 1887	York Iron Co	Charcoal	1	Black River Falls		Presented.
6542	Sept., 1887	Exchange	Nickeliferous jasper	1	Riddle, Dougl's Co., Or		From Wm. Q. Brown.
6543	Sept., 1887	Geol. Survey	Iron and copper	1	Tower, Minn		H. V. Winchell. Lee Mine.
6544	Sept., 1887	Geol. Survey	Hematite in quartz	1	Tower, Minn		H. V. Winchell. Lee Mine.
6545	Sept., 1887	Geol. Survey	Quartz crystals	4	Tower, Minn		H. V. Winchell.
6546	Sept., 1887	Geol. Survey	Hematite	1	Tower, Minn		H. V. Winchell.
6547	Sept., 1887	Geol. Survey	Red jasper conglomerate	1	Shores of Rainy Lake	Drift	H. V. Winchell.
6548	Sept., 1887	Geol. Survey	Coarse hornblende quartz	1	Winibigoshish dam		H. V. Winchell. From a boulder.
6549	Sept., 1887	Geol. Survey	Sand	Indef.	Rainy Lake		H. V. Winchell. Sec. 28, 71, 23.
6550	Sept., 1887	Geol. Survey	Iron from furnace	1	Black River Falls		N. H. Winchell.
6553	Nov., 1887	Geol. Survey	Hinckley sandstone	1	Cattle River quarry	Potsdam	N. H. Winchell.
6555	Jan., 1888	Presented	Coarse syenite	2	Red Wing	Drift	From Dr. G. A. Newman.
6556	Feb., 1888	Presented	Conocephalites hamulus, Hall	2	Winona, Minn	Silurian	From W. A. Finkelnburg.
6557	Feb., 1888	Presented	Platyceras minutissimum (Wal.)	3	Marine Mills, Minn	Silurian	From W. A. Finkelnburg.
6558	Feb., 1888	Presented	Bellerophon antiquatus (Wal.)	2	Osceola, Wis	Silurian	From W. A. Finkelnburg.
6559	Feb., 1888	Presented	Lingulepis pinnaformis, Owen	3	Taylors Falls, Minn	Silurian	From W. A. Finkelnburg. Short valve.
6560	Feb., 1888	Presented	Lingulepis pinnaformis	3	Taylors Falls, Minn	Silurian	From W. A. Finkelnburg. Long valve.
6561	Feb., 1888	Presented	Obolella polita, Hall	4	Dresbach, Minn	Silurian	From W. A. Finkelnburg.
6562	Feb., 1888	Presented	Chariocephalus whitfieldi, Hall	2	Wis. opp. Winona, M.	Silurian	From W. A. Finkelnburg. Glabella.
6563	Feb., 1888	Presented	Dikelocephalus osceola (Hall)	1	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Head.
6564	Feb., 1888	Presented	Dikelocephalus osceola	1	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Pygidium.
6565	Feb., 1888	Presented	Conocephalites minors Shum	3	Minneiska, Minn	Silurian	From W. A. Finkelnburg. Glabella.
6566	Feb., 1888	Presented	Conocephalites, Oweni Hall	4	Marine Mills, Minn	Silurian	From W. A. F'g. Glabella, fixed cheeks.
6567	Feb., 1888	Presented	Illænurus quadratus, Hall	2	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Free cheeks.
6568	Feb., 1888	Presented	Illænurus quadratus	3	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Glabella.
6569	Feb., 1888	Presented	Illænurus quadratus	2	Osceola Mills, Wis	Silurian	From W. A. Finkelnburg. Pygidium.
6570	Feb., 1888	Presented	Palæemon minneiskensis, Wal	8	Minneiska, Minn	Silurian	From W. A. Finkelnburg.
6576	Feb., 1888	Exchange	Felsyte	1	Sec. 17, T. 33, R. 5 (E), Mo		From Erasmus Haworth, Orig. No. 316
6577	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 9, T. 33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 317
6578	Feb., 1888						

6584	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 18, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 324
6585	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 9, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 325
6586	Feb., 1888	Exchange	Granite	1	Sec. 11, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 326
6587	Feb., 1888	Exchange	Granite	1	Sec. 9, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 327
6588	Feb., 1888	Exchange	Quartz-orthoclase	1	Sec. 20, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 328
6589	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 29, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 329
6590	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 21, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 330
6591	Feb., 1888	Exchange	Porphyry-orthoclase	1	Sec. 28, T. 33, R. 5, Mo	From Erasmus Haworth, Orig. No. 331
6592	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 29, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 822
6593	Feb., 1888	Exchange		1	Sec. 32, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 333
6594	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 32, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 334
6595	Feb., 1888	Exchange	Altered dioryte (?)	1	Sec. 32, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 335
6596	Feb., 1888	Exchange	Chert	1	Sec. 32, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 336
6597	Feb., 1888	Exchange		1	Sec. 32, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 337
6598	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 31, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 338
6599	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 31, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 339
6600	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 6, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 340
6601	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 6, T. 32, R. 5, Mo.	From Erasmus Haworth, Orig. No. 341
6602	Feb., 1888	Exchange	Diabase	1	Sec. 16, T. 32, R. 5, Mo.	From Erasmus Haworth, Orig. No. 342
6603	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 16, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 343
6604	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 15, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 314
6605	Feb., 1888	Exchange	Granite	1	Sec. 15, T. 33, R. 5, Mo	From Erasmus Haworth, Orig. No. 345
6606	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 27, T. 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 347
6607	Feb., 1888	Exchange	Diabase	1	Sec. 17, T. 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 348
6608	Feb., 1888	Exchange	Diabase	1	Sec. 17, T. 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 349
6609	Feb., 1888	Exchange		1	Sec. 19, T. 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 350
6610	Feb., 1888	Exchange		1	Sec. 19, T. 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 351
6611	Feb., 1888	Exchange		1	Sec. 5, T. 32, R. 5, Mo.	From Erasmus Haworth, Orig. No. 352
6612	Feb , 1888	Exchange		1	Mo.	From Erasmus Haworth, Orig. No. 353
6613	Feb., 1888	Exchange		1	Mo.	From Erasmus Haworth, Orig. No. 354
6614	Feb., 1888	Exchange		1	Mo.	From Erasmus Haworth, Orig. No. 355
6615	Feb., 1888	Exchange		1	Mo.	From Erasmus Haworth, Orig. No. 356
6616	Feb., 1888	Exchange		1	Mo.	From Erasmus Haworth, Orig. No. 357
6617	Feb., 1888	Exchange	Duplicate samples	14	Mo.	From Erasmus Haworth, Orig. No. .....
6618	Feb., 1888	Exchange	Altered diabase (?)	1	Sec. 4, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 358
6619	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 19, T, 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 360
6620	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 14, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 361
6621	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 18, T, 33, R. 6, Mo.	From Erasmus Haworth, Orig. No. 362
6622	Feb , 1888	Exchange	Granite	1	Sec. 4, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 363
6623	Feb., 1888	Exchange	Granite	1	Sec. 3, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 364
6624	Feb., 1888	Exchange	Diabase	1	Sec. 3, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 365
6625	Feb., 1888	Exchange	Diabase-porphyry	1	Sec. 10, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 366
6626	Feb., 1888	Exchange	Granite	1	Sec. 10, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 367
6627	Feb., 1888	Exchange	Granite	1	Sec. 11, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig No. 368
6628	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 11, T, 33, R. 5. Mo.	From Erasmus Haworth, Orig. No. 369
6629	Feb., 1888	Exchange	Diabase	1	Sec. 14, T, 33, R. 5, Mo.	From Erasmus Haworth, Orig. No. 370

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887–88.—(*Continued.*)

Serial No.	Obtained.		Name.	Number of Specimens.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
6630	Feb., 1888	Exchange	Granite	1	Sec.14, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 371
6631	Feb., 1888	Exchange	Quartz-porphyry	1	Sec.14, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 372
6632	Feb., 1888	Exchange	Decomposed conglomerate	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 373
6633	Feb., 1888	Exchange	Quartz-porphyry	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 374
6634	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.13, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 375
6635	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.24, T.34, R. 5, Mo.		From Erasmus Haworth, Orig. No. 376
6636	Feb., 1888	Exchange	Diabase	1	Sec.25, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 377
6637	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.25, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 378
6638	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.26, T.33, R. 5, Mo.		From Erasmus Haworth, Orig. No. 379
6639	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.35, T.33, R. 5, Mo.		From Errsmus Haworth, Orig. No. 380
6640	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec. 3, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 381
6641	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 8, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 382
6642	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Sec.10, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 383
6643	Feb., 1888	Exchange		1	Sec.16, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 384
6644	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.21, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 385
6645	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.21, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 386
6646	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 387
6647	Feb., 1888	Exchange	Altered diabase	1	Mo.		From Erasmos Haworth, Orig. No. 388
6648	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 389
6649	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 390
6650	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.17, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 391
6651	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec 20, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 392
6652	Feb., 1888	Exchange	Marble	1	Sec.18, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 393
6653	Feb., 1888	Exchange	Limestone	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 394
6654	Feb., 1888	Exchange	Quartzyte	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 395
6655	Feb., 1888	Exchange	Quartz-porphyry	1	Sec. 7, T.32, R. 5, Mo.		From Erasmus Haworth. Orig. No. 396
6656	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec. 7, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 397
6657	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec. 8, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 398
6658	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.30, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 399
6659	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec.30, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 400
6660	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.19, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 401
6661	Feb., 1888	Exchange	Orthoclase-porphyry	1	Sec.15, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No 402
6662	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.14, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 403
6663	Feb., 1888	Exchange	Plagioclase-porphyry	1	Sec.23, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 404
6664	Feb., 1888	Exchange	Altered diabase	1	Sec.23, T.32, R. 5, Mo.		From Erasmus Haworth, Orig. No. 405
6665	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 406

6666	Feb., 1888	Exchange	Plagioclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 409
6667	Feb., 1888	Exchange	Epidote-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 410
6668	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 411
6669	Feb., 1888	Exchange	Quartz-orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 412
6670	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 413
6671	Feb., 1888	Exchange	Orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 414
6672	Feb., 1888	Exchange	Orthoclase-porphyry	1	Mo.		From Erasmus Haworth, Orig. No. 415
6673	Feb., 1888	Exchange	Diabase	1	Mo.		From Erasmus Haworth, Orig. No. 416
6674	Feb., 1888	Exchange	Diabase	1			
6675	Feb., 1888	Exchange	Diabase	1			
6676	Feb., 1888	Exchange	Rewdanskite (?)	1	Riddles, Oregon		From W. Q. Brown.
6677	Feb., 1888	Exchange	Garnierite and serpentine	1	Riddles, Oregon		From W. Q. Brown.
6678	Feb., 1888	Exchange	Chrysoprase	1	Riddles, Oregon		From W. Q. Brown.
6679	Feb , 1888	Exchange	Garnierite (soft).	1	Riddles, Oregon		From W. Q. Brown.
6680	Feb., 1888	Exchange	Garnierite and chromic iron	1	Riddles, Oregon		From W. Q. Brown.
6681	Feb., 1888	Presented	Copper ore	1	Globe City, Arizona		From J. L. Vivian.
6682	Feb., 1888	Presented		1			
6683	April, 1888	Presented	Geyserite	Indef.	Lindsborg, Kans		From J. H. Udden.
6684	April, 1888	Exchange	Pentamerus oblongus, Saw	2	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6685	April, 1888	Exchange	Zaphrentis	2	Delaware Co., Ohio	Dev. Corn	From W. S. Hoskinson.
6686	April, 1888	Exchange	Zaphrentis	2	Delaware Co., Ohio	Dev. Corn	From W. S. Hoskinson.
6687	April, 1888	Exchange	Orthocerata	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6688	April, 1888	Exchange	Orthocerata	1	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6689	April, 1888	Exchange	Orthocerata	1	Miamisburg, Ohio	U. H'dn riv	From W. S. Hoskinson.
6690	April, 1888	Exchange	Cyathophylloid	3	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6691	April, 1888	Exchange	Cyathophyllod	4	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6692	April, 1888	Exchange	Strophodonta-hemispherica	1	Delaware Co., Ohio	Dev. Corn	From W. S. Hoskinson.
6693	April, 1888	Exchange	Strophomena-rhomboidalis	2	Waldron, Ind	Niagara	From W. S. Hoskinson.
6694	April, 1888	Exchange	Strophomena-rhomboidalis	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6695	April, 1888	Exchange	Illænus daytonensis	4	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6696	April, 1888	Exchange	Streptelamina	4	Miamisburg, Ohio	L. Sil	From W. S Hoskinson.
6697	April, 1888	Exchange	Favosites	2	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6698	April, 1888	Exchange	Favistella	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6699	April, 1888	Exchange		2		Dev. Corn	From W. S. Hoskinson.
6700	April, 1888	Exchange		1	Miamisburg, Ohio	Cincin	From W. S. Hoskinson.
6701	April, 1888	Exchange	Lithostration	1	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6702	April, 1888	Exchange	Eucalyptocrinus crassus	3	Springfield, Ohio	Niagara	From W. S. Hoskikson.
6703	April, 1888	Exchange	Eucalyptocrinus crassus	2	Waldron, Ind		From W. S Hoskinson.
6704	April, 1888	Exchange	Eucalyptocrinus (roots)	2	Waldron, Ind		From W. S. Hoskinson.
6705	April, 1888	Exchange	Crinoid stems	8	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6706	April, 1888	Exchange	Crinoid	1	Springfield, Ohio	Niagara	From W. S. Hoskinson.
6707	April, 1888	Exchange	Monticulipora dalii	2	Miamisburg, Ohio		From W. S. Hoskinson.
6708	April, 1888	Exchange	Calymene niagarensis	1	Springfield, Ohio		From W. S. Hoskinson.
6709	April, 1888	Exchange	Calymene senaria	1	Oxford, Ohio	U. Hud. riv	From W. S. Hoskinson.
6710	April, 1888	Exchange	Lichas brevipes	1	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.
6711	April, 1888	Exchange	Spirifera mucronata	1	Miamisburg, Ohio		From W. S. Hoskinson.
6712	April, 1888	Exchange	Atrypa reticularis	4	Delaware Co., Ohio	Dev. Corn.	From W. S. Hoskinson.
6713	April, 1888	Exchange	Platystoma niagarense	2	New Carlisle, Ohio	Clinton	From W. S. Hoskinson.

SPECIMENS REGISTERED IN THE GENERAL MUSEUM IN 1887-88.—(*Concluded.*)

Serial No.	Obtained. When.	Obtained. Whence.	Name.	Number of Specimens.	Locality.	Formation.	Collector and Remarks.
6714	April, 1888	Exchange	Platystoma niagarense	6	Waldron, Ind.		From W. S. Hoskinson
6715	April, 1888	Exchange	Eichwaldia reticulata	2	Waldron, Ind	Niagara	From W. S. Hoskinson.
6716	April, 1888	Exchange	Zygospira modesta.	3	Miamisburg, O.		From W. S. Hoskinson.
6717	April, 1888	Exchange	Leptæna sericea	3	Miamisburg, O.	Up. Hud. R	From W. S. Hoskinson.
6718	April, 1888	Exchange	Protarea vetusta,	2	Miamisburg, O.		From W. S. Hoskinson.
6719	April, 1888	Exchange	Murchisonia bellicincta	2	Miamisburg, O.		From W. S. Hoskinson.
6720	April, 1888	Exchange	Cyclonema bilix	1	Miamisburg, O.		From W. S. Hoskinson.
6721	April, 1888	Exchange	Pleurotomaria ro idophora	2	Miamisburg, O.		From W. S. Hoskinson.
6722	April, 1888	Exchange	Orthis simata	2	Miamisburg, O.	Up. Hud. R	From W. S. Hoskinson.
6723	April, 1888	Exchange	Orthis subquadrata.	9	Miamisburg, O.		From W. S. Hoskinson.
6724	April, 1888	Exchange	Orthis acutilirata.	4	Miamisburg, O.		From W. S. Hoskinson.
6725	April, 1888	Exchange	Orthis lynx	5	Miamisburg, O.		From W. S. Hoskinson.
6726	April, 1888	Exchange	Orthis faustra	1	New Carlisle, O.	Clinton	From W. S. Hoskinson.
6727	April, 1888	Exchange	Streptorhynchus sulcatus	1	Miamisburg, O.	Up. Hud. R	From W. S. Hoskinson.
6728	April, 1888	Exchange	Streptorhynchus planumbonus	3	Miamisburg, O.		From W. S. Hoskinson.
6729	April, 1888	Exchange	Streptorhynchus nutans	3	Miamisburg, O.		From W. S. Hoskinson.
6730	April, 1888	Exchange	Strophomena alternata	2	Miamisburg, O.		From W. S. Hoskinson.
6731	May, 1888	Presented	Pseudomorph of magnetite and pyrite after garnet.	1	Negaunee, Mich.		From N. H. Winchell.
6732	May, 1888	Presented	Rock 60 feet from surface.	4	Little Falls, Minn.		From N. H. Winchell, at L. F's Brew'y.
6733	May, 1888	Presented	Pyrite from [illegible] Ill.	1	Minnesota	Drift	From N. H. Winchell.
6734	May, 1888	Presented	Pseudomorph hematite	1	Marquette I. r., Mich.		From N. H. Winchell.
6735	May, 1888	Exchange	Tin ore	1	Pennington Co., Dak.		From Sam. Scott, Morgan's Tin Mine.
6736	May, 1888	Exchange	Greisen rock	1	Pennington Co., Dak.		From Sam. Scott, Everly Tin Mine.
6737	May, 1888	Exchange	Spodumene	1	Pennington Co., Dak.		From Sam. Scott, Etta Tin Mine.
6738	May, 1888	Exchange	Rose quartz	1	Pennington Co., Dak.		From Sam. Scott, Red Rose Mine.
6739	May, 1888	Exchange	Albite	1	Pennington Co., Dak.		From Sam. Scott, Etta Tin Mine.
6740	May, 1888	Presented	Albite	2	Amelia Co., Va.		G. L. English & Co., Amelia C't House.
6741	May, 1888	Presented	Lingula acuminata	1	New York	Medina Sand.	From Rev. H. Herzer.
6770	Aug., 1888	Presented	Piece of cedar wood	1	Near Camden, Minn.	Drift	From Cyrus R. Stone.
6824	Oct., 1888	Presented	Minerals from Mt Vesuvius.	12	Italy		From Mrs. M. J. Wilkin.
6825	Oct., 1888	Presented	Incrustation on gneiss	1	Near Swarthm're col, Pa.		From Miss M. L. Sanford.
6826	Oct., 1888	Presented	Meerschaum	1	Norway		Prof. J. Breda (From the edge of a glacier below Sulitind, Norway.)
6827	Oct., 1888	Presented	Lignite.	1	St. Paul, Minn.	Drift	Prof. N. H. Winchell.

VI.

PENDIX.—LIST OF RECENT GEOLOGICAL PUBLICATIONS RELATING TO THE CRYSTALLINE ROCKS.

VI.

LIST OF AMERICAN PUBLICATIONS BETWEEN 1872 AND 1889 THAT HAVE SOME RELATION TO THE CRYSTALLINE ROCKS OF THE NORTHWEST.

This list of publications, while embracing most of those issued since 1872 bearing on the crystalline rocks of Minnesota, or of the Northwest, is not presumed to be complete, and it is desired that geologists who discover omissions will communicate with the writer in order that, in a future report, such additions may be made as will make the list perfect.

The list of papers and other publications prepared by Whitney & Wadsworth and published in the *Bulletin of the Museum of Comparative Zoology*, Cambridge (Geol. Series, Vol. I.), carried the record up to 1880. By the aid of that, and with the assistance of Mr. Geo. H. Barton, of the Institute of Technology, Boston, who examined some serial publications that could not be consulted at Minneapolis, the catalogue may be considered to embrace most of the publications of American geologists on the crystalline rocks of the central and eastern portions of the United States and of Canada, between 1872 and 1889. There are, however, some important serials that have not been consulted.

1873.

BELL, ROBT.

Report on the country between lake Superior and lake Winnipeg. Geol. Sur. of Can., Report of Progress. Montreal, 1872-73, pp. 87-111.

BROOKS, T. B.

Geological Survey of Michigan, with maps, 1869-73, i.; Part I., Iron-bearing Rocks, 319 pp.; Part II., Copper-bearing Rocks, R. Pumpelly and A. R. Marvine, 143 pp.; Part III., Palæozoic Rocks, Charles Rominger, 105 pp.; ii., 298 pp., contains papers by Messrs. Brooks, Julien, Wright, Jenney, and Tuttle.

DANA, J. D.

On the Quartzite, Limestone, and Associated Rocks of the vicinity of Great Barrington, Mass., Am. J. Sci., 3d Series, Vol. 5, pp. 47-53, 87-91; Vol. 6, pp. 257-278.

FOSTER, J. W.

Ancient Mining by the Mound-builders in the "Prehistoric Races of the United States." Chicago, 1873, pp. 361–374.

HITCHCOCK, C. H.

Classification of the Rocks of New Hampshire. Proc. Boston Soc. Nat. Hist., Vol. 15, pp. 304–307.

HUNT, T. STERRY.

The Geology of the North Shore of Lake Superior. (Supplementary Note.) Trans. Am. Inst. Min. Eng., 1873, ii., 58, 59.

IRVING, ROLAND D.

On some points in the Geology of Northern Wisconsin. Trans. Wisc. Acad. Sci., 1873–74, ii., 107–119.

MARVINE, A. R.

Geology of Michigan. Part II., 1873.

NICHOLSON, H. ALLEYNE.

On the Geology of the Thunder bay and Shabendowan Mining Districts on the North Shore of lake Superior. Quart. Jour. Geol. Soc., 1873, xxix., 17–24.

PUMPELLY, RAPHAEL.

The Paragenesis and Derivation of Copper and its Associates on lake Superior. Am. Jour. Sci., 1872 (3), iii., 188–198, 243–258, 347–353: Leonhard's Jahrbuch, 1872, pp. 538–540; Geol. of Michigan, Part II., 1873.

SELWYN, ALFRED R. C.

Notes of a Geological Reconnoissance from lake Superior to Fort Garry. Geol. Surv. of Canada, Report of Progress. Montreal, 1872–73, pp. 8–18.

WHITTLESEY, CHARLES.

On the cause of the Transient Fluctuations of Level in lake Superior. Proc. Am. Assoc. Adv. Sci., 1873, xxii., Part II., 42–46.

WINCHELL, ALEXANDER.

The Diagonal System in the Physical Features of Michigan. Am. Jour. Sci., 1873 (3), vi., 36–40.

WINCHELL, N. H.

Geological and Natural History Survey of Minnesota. First annual report, 113 pp.

WING, A. T.

Concerning the Spontaneous Movements and Fractures of Rock, at Quarry of W. N. Flynt, Monson, Mass. Proc. Bost. Soc. Nat. Hist., Vol. 16, pp. 41–42.

1874.

ALLEN, J. A.

Metamorphism Produced by the Burning of Lignite Beds in Dakota and Montana Territories. Proc. Boston Soc. Nat. Hist., Vol. 16, pp. 246–262.

ROWN, A. J.

The Formation of Fissures and the Origin of Their Mineral Contents. Trans. Am. Inst. Min. Eng., 1874, ii., 215–219.

ANA, JAMES D.

Manual of Geology, New York, 1st ed., 1862, 800 pp.; 2d ed., 1874, 828 pp.; 3d ed., 1880, 911 pp.

OUGLAS, JAMES.

The Native Copper Mines of lake Superior. Quart. Jour. Sci., 1874, xi., 162–180; Canadian Nat. and Geol., 1874 (2), vii., 318–336.

VING, ROLAND D.

On the Age of the Copper-bearing Rocks of lake Superior; and on the Westward Continuation of the lake Superior Synclinal. Am. Jour. Sci., 1874 (3), viii., 46–56.

E CONTE, J. L.

On Coracite, a new ore of Uranium. Am. Jour. Sci., 1874 (2), iii., 173–175.

KELLAR, PETER.

Mining on the North Shore of lake Superior. Toronto, 1874, 26 pp.

EWBERRY, J. S.

The Iron Resources of the United States. International Review, 1874, ii., 754–780.

CHOLSON, H. ALLEYNE.

On the Mining District on the North Shore of lake Superior. Trans. of North of England Inst. of Min. and Mech. Eng. Newcastle-on-Tyne, 1874–75, xxiv., 237–249, with maps.

HITTLESEY, CHARLES.

Sudden Fluctuations of Level in Quiet Waters. Records of Observations. Proc. Am. Assoc. Adv. Sci., 1874, xxiii., 139–143.

1875.

ERMANN, H. W.

Die Kupferführenden Schichten am lake Superior. Sitzungs-Berichte der naturwissenschaftlichen Gesellschaft Isis in Dresden, 1875, pp. 101–105.

LL, ROBERT.

The Mineral Region of lake Superior. Canadian Nat. and Geol., 1875 (2), vii., 49–51.

AKE, WILLIAM P.

The Mass Copper of lake Superior Mines, and the Method of Mining it. Trans. Am. Inst. Mining Engineers, 1875, iv., 110–112.

APMAN, E. J.

An Outline of the Geology of Ontario, based on a Subdivision of the Province into Six Natural Districts. Canadian Jour., 1875 (2), 580–588.

CHESTER, ALBERT H.

On the Percentage of Iron in Certain Ores. Trans. Am. Inst. Min. Eng., 1875, iv., 219.

DODGE, W. W.

Notes on the Geology of Eastern Massachusetts. Proc. Boston Soc. Nat. Hist., Vol. 17, pp. 388–419.

HUNT, T. STERRY.

The Decayed Gneiss of the Hoosac Mountains. Ibid., Vol. 18, pp. 106–108.

The Development of our Mineral Resources. Harper's Magazine, 1875, li., 82–94.

PUMPELLY, RAPHAEL.

On Pseudomorphs of Chlorite after Garnet at Spurr Mountain Iron Mine. Am. Jour. Sci., 1875 (3), x., 17–21.

SAUVAGE, E.

Notice sur les Minerais de Fer du lac Supérieur. Annales des Mines, 1875 (7), viii., 1–35.

WHITTLESEY, CHARLES.

Physical Geology of lake Superior. Proc. Am. Assoc. Adv. Sci., 1875, xxiv., 60–72.

WINCHELL, N. H.

The Geology of the Minnesota Valley. Second Report on the Geol. and Nat. Hist. Surv. of Minnesota, pp. 127–212.

1876.

BELL, ROBERT.

Report on an Exploration in 1875, between James bay and lakes Superior and Huron. Geol. Surv. of Canada, Report of Progress, 1875–76, pp. 294–342.

BRADLEY, FRANK H.

On a Geological Chart of the United States East of the Rocky Mountains and of Canada. Am. Jour. Sci., 1876 (3), xii., 286–291.

BROOKS, T. B.

On the Youngest Huronian Rocks, South of lake Superior, and the Age of the Copper-bearing Series. Am. Jour. Sci., 1876 (3), xi., 206–211.

Classified List of Rocks observed in the Huronian Series, south of lake Superior, etc. Am. Jour. Sci., 1876 (3), xii., 194–204.

BOUVÉ, T. T.

On the Origin of Porphyry. Proc. Boston Soc. Nat. Hist., Vol. 18, pp 217–220.

CHAPMAN, E. J.

On the Leading Geological Areas of Canada. Canadian Jour., 1876 (2), xv., 92–122.

CREDNER, HERMANN.

Elemente der Geologie. 1st ed., 1872; 2nd ed., 1872; 3rd ed., 1876; 699 pp., 4th ed., 1880.

EGGLESTON, THOMAS.

Boracic Acid in lake Superior Iron Ores. Trans. Am. Inst. Min. Eng., 1876, v., 131, 132.

GEINITZ, H. B.

Alexander Winchell: über geologische Verhältnisse in Michigan. Leonhard's Jahrbuch, 1876, pp. 438–440.

HOUGHTON, JACOB, Jr.

The Ancient Copper Miners of lake Superior. Iron, 1876 (N. S.), viii., 168, 169, 199; Swineford's Copper, Iron, and other Material Interests of lake Superior. Marquette, 1876, pp. 78–89.

HUNT, T. STERRY.

On the History of the Crystalline Stratified Rocks. A. A. A. S. Vol. 25, pp. 205–208.

HYATT, ALPHEUS.

Remarks upon above paper, and upon the Geology of Marblehead Neck. Proc. Bost. Soc. Nat. Hist., pp. 220–224.

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ROMINGER, CHARLES.

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Notes on the Geology of Northern Wisconsin. Trans. Wisc. Acad., 1875–76, iii., 40–55.

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WHITTLESEY, CHARLES.

On the Origin of Mineral Veins. Proc. Am. Assoc. Adv. Sci., 1876, xxv., 213–216.

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The North Shore of lake Superior as a Mineral-bearing District. Trans. Am. Inst. Min. Eng., 1877, v., 473–487.

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IRVING, ROLAND D.

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Ueber die Krystallinischen Gesteine von Minnesota in Nord-Amerika. Neues Jahrbuch für Mineralogie, Geologie und Palæontologie, 1877, 31–56, 113–138 and 225–242. (Translation in the eleventh annual report of the Geological Survey of Minnesota.)

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CHAMBERLIN, T. C.

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HUNT, T. STERRY.

Chemical and Geological Essays. Boston, 1874, 489 pp.; Revised Edition, Salem, 1878.

Azoic Rocks, Part I., 1878. Second Geol. Surv. of Penn., E, 253 pp.

On the Geology of the Eözoic Rocks of North America. (Abstract.) Proc. Boston Soc. Nat. History, Vol. 19, pp. 275–79.

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Elements of Geology; a text-book for colleges and for the general reader. New York, D. Appleton & Co., 588 pp., 8vo.

LAFLAMME, L'ABBÉ J. C.

Note sur le Contact des Formations Paleozoiques et Archéennes de la Province de Quebec. Trans. Roy. Soc. Canada, Vol. IV., Sec. IV., pp. 43–47.

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Geologist's Traveling Hand-book, New York, 1878, 261 pp.

PUMPELLY, RAPHAEL.

Metasomatic Development of the Copper-bearing Rocks of lake Superior. Proc. Am. Acad., 1878, xiii., 253–309.

SELWYN, ALFRED R. C.

- The Stratigraphy of the Quebec Group and the Older Crystalline Rocks of Canada. Geol. Surv. of Canada, Report of Progress, 1877–78, A. 15 pp. Reprinted in the Canadian Nat. and Geol., 1879 (2), ix., 17–32.

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The lake Superior Copper Rocks in Pennsylvania. Trans. Am. Inst. Min. Eng., 1879, vii., 331–333, 336.

CHAMBERLIN, T. C.

Geology of Wisconsin. 1873–79, iii., 763 pp., with maps. Reports by Messrs. R. D. Irving, R. Pumpelly, A. A. Julien, C. E. Wright, E. T. Sweet, T. B. Brooks, A. Wichmann, T. C. Chamberlin, and T. S. Hunt.

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On the Hudson River Age of the Taconic Schists, and on the Dependent Relations of the Dutchess County and Western Conn. Limestone Belts. Am. J. Sci., 3d series. Vol. 17, 375–388; Vol. 18, pp. 61–64.

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A Microscopical Study of some Huronian Clay Slates. Quart. Jour. Geol. Soc., 1879, xxxv., 156–164.

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1880.

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BELL, ROBERT.

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MBERLIN, T. C.

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›ology of Frenchman's Bay, Maine. Bost. Soc. Nat. Hist. Proc., Vol. 21, pp. 109–117.

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ı the Geological Relation of the Limestone Belts of Westchester County, New York. Am. Jour. Sc., Vol. 20, pp. 26–32, 194–220, 359–375, 450–456; Vol. 21, pp. 425–443; Vol. 22, pp. 103–119, 313–315, 327–335.

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IS, D. C.

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ER, J. S.

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D, S. W.

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KIE, ARCHIBALD.

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L, C. W.

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T, T. STERRY.

ıe History of some Pre-Cambrian Rocks in America and Europe. Am. Jour. Sci., iii., Vol. 19, pp. 268–283.

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MARCOU, JULES.

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Bost. Soc. Nat. Hist. Proc., Vol. 20, pp. 470-479.

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THE SIXTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1887. 504 pp.: 8vo.; two plates and 83 other illustrations. Contains reports on the original Huronian area, the Marquette iron region, on the Gogebic and Penokee iron-bearing rocks, on the formations of Northeastern Minnesota (including the physical aspects, vegetation, quadrupeds and other vertebrates), the geology of the region northwest from Vermillion lake to Rainy lake and of the Little and Big Fork rivers; also notes on the Molluscan fauna of Minnesota.

II. FINAL REPORT.

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E GEOLOGY OF MINNESOTA. VOL. II OF THE FINAL REPORT. 1882-1885. xxiv. and 695 pp., quarto; illustrated by 42 plates and 32 figures. By *N. H. Winchell*, assisted by *Warren Upham*, containing chapters on the Geology of Wabasha, Goodhue, Dakota, Hennepin, Ramsey and Washington counties, by *N. H. Winchell*, and on Carver, Scott, Sibley, Nicollet, McLeod, Renville, Swift, Chippewa, Kandiyohi, Meeker, Wright, Chisago, Isanti, Anoka, Benton, Sherburne, Stearns, Douglas, Pope, Grant, Stevens, Wilkin, Traverse, Otter Tail, Wadena, Todd, Crow Wing, Morrison, Mille Lacs, Kanabec, Pine, Becker and Clay counties, by *Warren Upham*. Distributed according to law in the same manner as Vol. I above.

III. MISCELLANEOUS PUBLICATIONS.

CIRCULAR No. 1. A copy of the law ordering the survey, and a note asking the co-operation of citizens and others. 1872.

PEAT FOR DOMESTIC FUEL. 1874. Edited by *S. F. Peckham*.

REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. A history of all official transactions relating to them, and a statement of their amount and location. 1874. By *N. H. Winchell*.

A CATALOGUE OF THE PLANTS OF MINNESOTA. Prepared in 1865, by *I. A. Lapham*, contributed to the Geological and Natural History Survey of Minnesota, and published by the State Horticultural Society in 1875.

CIRCULAR No. 2. Relating to botany, and giving general directions for collecting information on the flora of the state. 1876.

CIRCULAR No. 3. The establishment and organization of the Museum. 1877.

CIRCULAR No. 4. Relating to duplicates in the Museum and exchanges. 1878.

THE BUILDING STONES, CLAYS, LIMES, CEMENTS, ROOFING, FLAGGING AND PAVING STONES OF MINNESOTA. A special report by *N. H. Winchell*. 1880.

CIRCULAR No. 5. To Builders and Quarrymen. Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the General Museum. 1880.

CIRCULAR No. 6. To owners of mills and unimproved water-powers. Relating to the Hydrology and water powers of Minnesota. 1880.

IV. BULLETINS.

1. History of Geological Surveys in Minnesota. By *N. H Winchell*.
2. Preliminary Description of the Peridotytes, Gabbros, Diabases and Andesytes of Minnesota. By *M. E. Wadsworth*.
3. Report of work done in Botany in the year 1886. By *J. C. Arthur*.
4. A Synopsis of the Aphididæ of Minnesota. By *O. W. Oestlund*.
5. Natural Gas in Minnesota. By *N. H. Winchell*.

THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF MINNESOTA.

The Eighteenth [illegible]

[illegible]

THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF MINNESOTA.

The Eighteenth Annual Report, for the year [illegible]

N. H. WINCHELL,

State Geologist.

THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF MINNESOTA.

The Eighteenth Annual Report, for the year 1889.

N. H. WINCHELL,

State Geologist.

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ADDRESS.

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, March 3, 1890.

To the President of the University.

DEAR SIR: With the round of another year I herewith report the progress made in the geological and natural history survey of the state. During the year there has been considerable interruption incident to the removal and installment of the museum and survey headquarters in the new Science Hall. This was aggravated by the fire which unfortunately broke out in the building in the latter part of December, and which, while not consuming much, yet so damaged the rooms and their contents that it necessitated the renovation of the entire building, and the cleaning of most of the specimens and apparatus. This report gives an idea of the progress that is being made in the intricate geology of the northeastern part of the state, and of the economic resources that are being developed there. That part which discusses the iron ores of the state is planned to be published as a separate bulletin of the survey.—Bulletin No. 6. It is accompanied by numerous illustrations and a geological map.

Respectfully, your obedient servant,
N. H. WINCHELL,
State Geologist and Curator of the General Museum.

REPORT.

I.

SUMMARY STATEMENT FOR 1889.

ere was not much field-work done in 1889. This was due to
hange from field-work to office and laboratory work which was
unced in the last annual report incident on the commencement
e final report on the northern part of the state. In July, how-
a special reconnoissance was made of the iron-deposits and
mines at Tower and Ely, in order to get some details of the
ions of the ore-bodies to the country rock as developed about
vorks, and of the methods of mining and transportation. In
directions this review was extended into the surrounding
try whenever there was promise of new facts either economic
ientific. This re-examination resulted in the acquirement of
any interesting facts of detail, and in the establishment or the
tion of some hypotheses as to the origin of the ore bodies, and
genetic history of the rocks embracing them. It was thought
with the light of the field observations made during the pre-
s three years fresh in mind, and with all the known theories of
re and of the general geology that had been proposed whether
e Minnesota survey or by others, immediately and continually
r test and application, such a careful investigation would be a
able preparation for the discussion of the crystalline rocks
h was contemplated, and especially for the exposition of the
ores contained in Bulletin No. 6. This review was made in
unction with Mr. H. V. Winchell; and inasmuch as the pro-
s of the investigation here, as elsewhere, has been frequently
esult of our joint work and mutual co-operative study, the
etin devoted to the iron ores herewith transmitted bears our
t authorship.

ithin the past year two other bulletins have been published,
Natural Gas in Minnesota, and *The History of Geological*
veys in Minnesota.

he Legislature of 1889 failed to make provision for the publica-
of the two final volumes of the survey report referred to in the

last annual statement. This failure, however, was not due so much to indifference on the part of the Legislature as a whole, as to the unfriendly manipulation of some of the committees, and the neglect of the public officials having in charge the estimates and recommendations for the current expenses. The reports of the survey were eagerly sought by all the legislators, both for themselves and for their friends. They were aggrieved when they found that by law this distribution was not wholly gratuitous and instant, and they desired the publication of the final volumes as fast as they can be got ready. The bill for a law, however, making provision by a money appropriation for the printing of the manuscripts now on hand was delayed by the chairman of the committee having it in charge until it was too late to get the appropriation allowed by the general finance committee and acted on by both houses of the Legislature. The same will be offered for publication at the next session of the Legislature (1891).

In the summer of 1889 the museum and all the paraphernalia of the survey were removed from the "main building" of the University, where it has been located since 1872, to the new Science Hall. The building was not yet completed, but the removal had to be made to give opportunity to fit the old rooms for other use prior to the opening of the fall term of the University. The building was nearly finished, and some work had been given to the museum and to the equipment of the various rooms, and plans had been entered upon for office and laboratory work, when another interruption was suffered (Dec. --) by the (supposed) spontaneous starting of a fire in the engine room, where painters had been at work with naphtha and white lead. This kept the survey work largely in abeyance till about Feb. 15, 1890, when the building had been again sufficiently restored, and the damaged rooms renovated, to permit of their regular occupancy. Thus it will be seen that the work of more than six months has been so broken and unsatisfactory that it will not permit a very cheerful view to be taken of the aggregate progress of the year. Still, unless some other unfavorable cause interfere, the commodious rooms now occupied by the survey for office, drafting room, laboratories, museum and storage, will, when fully equipped with apparatus, and the library with reference books, warrant the expectation that the nicer researches that remain to be done in order to "finish" the survey of the state, will go forward with ease and dispatch.

The Museum now needs replenishing. The room that is given to it is more than four times as large as that which it occupied in the other building, and numerous new cases ought to be constructed.

This is true particularly of the zoological collections, which have been put in the special charge of professor Nachtrieb. In the geological museum, while the old cases have been refitted and made to answer for the present, there is a need of mineralogical specimens and there will be soon need of other cases for exhibition. Some of the specimens of the Kunz collection purchased in 1876 have been lost. Many of them are permanently removed from exhibition in the museum and stored in the geological lecture room. Indeed many of the unique and attractive specimens formerly kept in the museum for exhibition have been missing from their places from that cause for some years, and some have been badly damaged. The mineral collection has thus inevitably deteriorated, and ought to be replenished by occasional purchase. Of course donations aid in keeping the collections (i. e. the cases) apparently full, but donations do not supply first-class material.

State Park. I wish to call the attention of the regents, and through their report, the attention of the public and the Legislature to the propriety of asking a reservation of land for a state park in some section in the northern part of the state. The geographic positon of Minnesota is on that border land which exhibits the transition of the forested area into the prairie. It hence preserves the faunal and floral characteristic of both, and within its territory must be studied by naturalists the mutual modifications and interchanges which the near neighborhood and contact of different physical features always imprint on the native vegetation and animal life found therein. By settlement and long habitation the natural conditions are destroyed and the natural laws that could perhaps be discovered by an examination of them in their original state, are never known. Hence as long as the natural conditions exist the state of Minnesota will be visited by students and collectors interested in natural science for the purpose of investigation, and this will bring Minnesota into prominent recognition in scientific literature and secondarily into scientific and economic research. It hence behooves the State to preserve, to such extent as may be found desirable and feasible, these natural and aboriginal conditions, and for this purpose there is no better method than to reserve from sale and settlement some considerable tract where they may not be destroyed.

Again the state should have a large public park because of the healthful resort that it ould afford for those living in cities, and for those who, coming from further south, seek in summer the invigorating effect of northern latitudes. The attractions of a multitude of lakes, rivers and rivulets of limpid and pure water, are confined in the United States, to the northern tier, where the tumuli of the glacial epoch formed the depressions and natural reservoirs of gravel and sand, such as mark its moraines from Maine to Minnesota. In Dakota these lines of tumuli pass across the prairies northwestward to the line of British America and do not return again sensibly within the United states, Hence it is within Minnesota that exists the last opportunity to preserve the pristine conditions of that unique combination of physical and faunal relations which alike distinguishes them from all other natural surface conditions in the United States, and has attracted to them always the venturesome, wandering explorer, the artist, the geologist, and the hardy frontier settler.

This park should be located either in the region northeast of lake Superior, enclosing some of the rock-bordered and rock-bottomed lakes that are a natural curiosity to every traveler, or in the area about the head waters of the Mississippi. General J. H. Baker, when surveyor-general of Minnesota, some years ago, urged that such a park be established on the international boundary line north of lake Superior, and specified the region of lake Saganaga. Since then, the region of the Itascan source of the Mississippi river has come into prominence, and it has served as the topic of several explorations and new "journals," which have given it already a renown equal to the earlier historic interests that cling to it since the days of Lieut. Allen, of H. R. Schoolcraft and Jean Nicollet. These artificial elements enter strongly into the question of making the selection for a state park, and bear heavily in favor of the sources of the Mississippi for such a selection. There is, fortunately, a perfect exemplification of the natural surface features that characterize the glacial moraines of the state within a few miles of the Itasca lake, and, indeed, they give outline and location to the entire Itascan basin, and would thus serve to embrace within easy access or in combination, both the natural and the artificial considerations. This region is, moreover, remote from lake Superior, and its attractions, by contrast with the surrounding country, would be hightened in the mind of every visitor. Whereas, in the northeastern part of the state, lake Superior and its attendant waters and surrounding hills, dominate the district, so that no selection could be made whose attractions would rise above those of the great lake itself.

It is presumed that there would be no difficulty, whether in the northeastern or the northwestern part of the state, or even in both, in getting the consent and cooperation of the United States government by the withdrawal of the lands concerned from the market, and perhaps of any private parties who may have received some of the lands from the United States, or from the State of Minnesota. At any rate, no time should be lost in entering upon the project, because of changes and increased difficulties that will render it impossible not many years hence.

The laboratory and office of the survey ought to be supplied with apparatus and books needed for the work that lies immediately before it. This is a matter of absolute necessity. It were better that all other expenses cease entirely till there be sufficient funds for this necessity, or that a special appropriation be made by the Legislature to provide them.

II.

Record of Field-Observations in 1888.

On the Mesabi Iron Range. Mallmann's mining camp is on the Duluth and Iron Range railroad, about two miles south of Hinsdale on the Giant's range of granite hills. The working is for iron ore. There are a number of pits or shafts sunk to the rock, from 15 to 50 feet in depth, and they have uniformly encountered the same magneto-bedded rock that Chester did on the Mesabi range a few miles further northeast* and of a character identical with that seen near the west end of Gunflint lake,** both being a part of the Animike, and probably in the lower portion of it. About half a mile further south is a cut by the railroad in real Animike slate. Some of the ore he finds is hematite, and he hopes to get enough that is hematite to warrant his enterprise. This working is just west from the "red cut" which is mentioned in the 13th report in giving a description of a trip to Tower, and in one of the shafts he has struck this red hematite mass. The rock seems to be more rotted in this red mass.

This magneto-bedded rock is nondescript. It has been referred to sometimes as quartzyte, but it generally contains not enough free quartz to entitle it to that designation. It is gray, medium-grained, sometimes fine-grained, has a mineral, apparently a feldspar, that changes by rot to a white kaolinic substance, or to a rusty powder, and is the rock in which is scattered the magnetite ore both here and at Gunflint lake, as well as at Chub (Akeley) lake. This ore is in lenticular bunches, elongated in the direction of the general bedding, and is generally not pure magnetite, but is seen to increase and fade again in the midst of the rock, sometimes extending in parallel bands from half an inch to an inch wide, and a foot or more in length. It is this same rock which accompanies the hematite, which inspires Mallmann with fresh hope. Apparently the hematite is disseminated in it in the same way as the magnetite. Mallmann is confident the ore here is the same as the ore mined at Tower, and in the same kind of rock—a mistake which we tried to correct. There is no question but the vertical greenish schists and graywackes seen at the Tower mines are repeated south of the Giant's range. and pass uncomformably below the Animike along the line of strike all the way from Gunflint lake to this point, and that they may be encountered after passing through the slates and quartzytes of the Animike. It is likely also that they are as apt to carry iron-ore lenses on the south side of that range as on the north side. But owing to the prevalence of the drift, and the concealment of these schists by the overlapping of the Animike, it would be a herculean and problematical task to seek to find such ore bodies by shafting through the Animike. It would not be impossible that a shaft should go down through the Animike, and should encounter one of these ore bodies in the Keewatin, but the chances against such an event would be many thousands to one. It is probable therefore that all the ore found by Mallmann here is from the Animike beds.

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* See Eleventh Annual Report, p. 156

** See Sixteenth Report. pp. 80. 267.

Observations about Tower. We visited again the vertical black slaty crag north of Tower, in the southern slope of the south ridge (photographed in 1886), and noted the abrupt and uncomformable transition from the slate to the green schist. This occurs a little west from the crag, and in a lower place. There is no indication that either underlies or overlies, as the line of contact is on a nearly horizontal plane surface. The structure and bedding of the slate is interrupted somewhat obliquely by that of the schist, and shows plainly some kind of unconformity. This slate is siliceous and has all the banding of the jaspilyte, but is not colored. A little further north it is like jaspilyte. Indeed, it passes into the rock which is, or which becomes, or which embraces the ore.

Thence we went further west and after considerable search we found the low, bare, slaty knoll, consisting of fissile slate, which was mentioned in the report of **1886, in which was recorded a gradual passage from the clay slate to the chlorite slate of the region. We examined it to find sedimentary banding. While this banding is not, in the knoll, characteristically exhibited, yet there are some long, parallel, color-bands, about one-sixteenth to one-half inch wide, that appear to be due to sedimentary action. It is noteworthy that throughout this knoll of clay slate, generally no such bands are visible. This may be due to the shattered condition of the rock and the obliteration of an original structure by the process of acquiring the slatiness. Toward the east, the slate, followed along the strike, *evidently gets more and more siliceous*, till, after some intervals of non-observation due to drift and to brush, it is converted into jaspilyte, first passing through the condition of the slate crag described above. But there is in the midst of this slate, further east, a little greenish, coarse sericitic and quartzose slaty-rock (No. 1505), apparently alternating with the clayey slate, which may be the parallel of the schist seen to alternate with the jaspilyte rock, as at the railroad cut south of the Stone mine. This indicates that, as formerly supposed, there is a close alliance between the clay slate and the green schist, or at least *a schist* which cannot with any certainty *or satisfaction be distinguished from it*, and again an alliance that implies some community of origin and structure between all three of these schists. In following the strike along toward the east from this knoll we saw a bed about fourteen inches thick of such green schist (but rather darker and coarser grained), *imbedded in the jaspilyte*[*]. The lack of sedimentary signs (*i. e.*, the general lack) caused me to query whether the eruptive green schists could become changed to argillyte, but on finding some, not very distinct, trace of bedding, and especially on seeing the argillyte bed change, in the direction of its strike, apparently first to siliceous slate and then to jaspilitic beds, the conclusion is found inevitable that the argillyte at least is an originally sedimentary rock.

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*Compare H. V. Winchell's report on this region. 17th report, pp. 88-9.

**Fifteenth report. p 267.

But this leaves to still be accounted for the green (or gray when siliceous) schist which usually resembles closely the green schist which is supposed to be of originally eruptive origin, seen interbedded with the argillyte. On the suppositions that it is of identical genetic origin with the eruptive green schist, it may be supposed to have been brought there by slight eruptions at the time of the sedimentation of the argillyte, and that would rather require that all the supposed eruptive green schist which embraces the jaspilyte, originated in the same way, *i. e*, in a manner similar to the eruptive sheets of the Cupriferous, and is now interbedded in the great (Keewatin) formation, as schists, in the same manner. This would make the eruptive green schists date from the time of the Keewatin itself, and the green schists would be found to be, on a large scale, conformable with the adjacent rock, instead of being of the nature of later overflows and uncomformable with it. The latter supposition was expressed in the 15th annual report.* I do not know that there is any necessary and known objection to that hypothesis. It would be necessary still to account for the rock having now the condition and structure of a schist and for its being sometimes the matrix for a multitude of fine pebbles of jaspilyte.

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[*] Compare Bulletin No. 6, where such a layer of silicious green schist is described on the north slope of the "north ridge," embraced in the contorted jaspilyte.

But it is not by any means certain yet that this gray schist (1505) is identical with, or can be found to grade into, the great body of green schist of the region, so that they can be embraced in the same general hypothesis.

We went over the south ridge at the Lee mine and west from there, and the following facts were noted:

1. In some places the jaspilyte is wonderfully brecciated over large areas, the same parts again cemented by the ferruginated granular silica, or by the same in a finer breccia, so that the general mass is as hard as the jaspilyte unbroken, and in this condition shows large glaciated areas.
2. When broken less minutely the cement is, in some other places, pure hematite, and when this has accumulated in large enough masses, filling pre-existing cavities whose forms it takes on, it is valuable as ore, and as such is the principal basis of the working of the Lee mine.
3. This accumulation of hematite, or re-cementation, took place before the deposition of any vitreous silica, or before any observable "silicification."
4. Chemical (*i. e.*, vitreous) silica was afterward deposited in openings and geodes in this hematite, and in veins crossing both the hematite and the jaspilyte, this being the last observable step.
5. I do not see hematite veins crossing chemical silica veins.
6. Hematite veins cross jaspilyte in all its forms, whether in breccia or as undisturbed strata in the jaspilyte.
7. Chemical silica veins and nodules occur latest and cross the hematite and also the jaspilyte.

This seems to show that there were two processes after the deposition of the original sediments forming the jaspilyte, viz., a ferruginization and a silicification, and that the former preceded. But, as already argued in the fifteenth report, the chalcedonic silica was not concerned in either of them, except that the rounded grains have become angular by deposition of interstitial silica. Samples 1506 show the relations of the chemical silica to the hematite, and 1507 show the brecciated jaspilyte cemented by a finer breccia of the same.

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*Page 221, 269, 322.

On Chester Peak (or Jasper Peak, so generally called at Tower), on the northwest side and shoulder, the jaspilyte dips north at an angle of about eighty degrees. It suddenly changes and dips west at seventy-five degrees, then as suddenly changes and dips east at seventy-five degrees. It then veers round on the apex of the hill so as to dip northeast at seventy degrees. In the easterly part, which is lower, the dip is north again. The hill is abrupt and short, but elongated about east and west. A stretch of drift, like a morainic ridge, rising about fifty feet, connects the hill with the "north ridge," in which are the mines of the Minnesota Iron Company; but there seems to be no rock-ridge uniting them. The "north ridge" dies out toward the east, although a series of low hills, making a lower range, can be seen to run along the south side of Vermilion lake and eastward. Toward the south the range of the Giant's hills can be seen from where it rises, on the south side of Birch lake to where they run out in the distance toward the west. They have openings and sudden elevations, but are without any notable peaks, the highest and apparently the most important hills being toward the southwest rather than south.

Numerous pits have been sunk by the iron company to the rock in the vicinity of this peak, and between it and the "north ridge". Some of them strike green schist, some a jaspilyte without ore, or a lean ore, and some of them reveal good ore. But in one of them, at the northwestern base of the peak, a black schist, soft and (carbonaceous?) holding balls of pyrite (1508) from a bullet's size to two and a half inches in diameter, was met in the bottom of the shaft. On the northern face of this hill are the green schists, seen at the mines, mixed and twisted with the jaspilyte. A deep drill hole on the south side of this hill afforded the diamond drill a core of porphyrel at several hundred feet below the surface, the hole sloping north.

Glaciated surfaces are seen nearly to the top, and a few boulders lie on the very top.

Some small veins in the brown jaspilyte consist of white chalcedonic silica (1509) crossing the jaspilyte banding. In the immediate vicinity are deposits of chemical silica. The existence of chalcedonic veins is a very rare occurrence, and has been observed, though doubtfully, but once before. Compare the fifteenth report, p. 324, and rock sample 1013. There must be some way to account for these chalcedonic veins. They do not appear to have been formed by mechanical transposition of laminæ in or across the jaspilyte strata. They do not have any banding or crystallization like true veins. They form a network connecting a coarse (and in some places a fine) breccia of brown fine-laminated jasper. These are on the exposed upper surface of the glaciated apex of the knob. The silica is white, and appears to have the effect and disposition of vein matter but not its structure. This hill is in nw ¼ ne ¼ sec. 35, 62-15.

At Ely. The rock-cuts all the way from Tower to Ely, so far as seen from the train, are all in the green schist, or a green rock more massive than schist which imperceptibly takes its place, and at Ely is the rock which has there been described in the field-observations of 1886 (Fifteenth Report, pp. 325-26), and which extends from Ely to the shore of Shagawa (Long) lake, and really which goes also to Fall lake and there forms the falls. At the rail road cut at Ely it exhibits some new features, viz:

1. It is made up of rounded masses of itself, or rock like itself, some of them four feet across, and some not more than three inches.

2. The rock matter between the rounded masses is darker green than the rounded boulders, and squeezes among them in the same manner as green schists between jaspilyte boulders at Tower. It is also more apt to be a little schistose.

3. There is no bedding like sedimentation, but an angular coarse jointage like that of eruptive rock which has flowed in a broad sheet over the surface. The forms of these boulders are visible in the weathered surface, and their slickensided (and then darker) exteriors are shown on the face of the railroad cut.

4. The boulders are frequently amygdaloidal, calcite being the mineral enclosed; but the cavities are rendered conspicuous by the easy weathering out of the calcite.

5. There is a crust of somewhat darker rock that surrounds the interior of the boulders, and these cavities are most abundant in it; they are commonly in the form of tubes that cross this crust approximately at right angles, radiating as from the centre, though not reaching the centre. Transverse to these tubes this crust sometimes exhibits a dim linear structure that appears to be fluidal.

6. This green rock contains chalcedonic silica, disseminated all through it, and it seems to result from a change in the chemical silica

7. This green rock is of the same genetic nature, and the same in all its physical aspects, with the exception of such as can be re[illegible] difference of weathering, as the Stuntz Island conglomer-

ate, but the enclosed boulders are less siliceous than the most of those in that conglomerate.

8. The rock that embraces these boulders is not usually, but is rarely, amygdaloidal. This is the rock which I designated, in this vicinity last year (1887), and before*, as modified graywcake, but it seems now never to have been in the form of graywacke.

No. 1510 is a sample of this green rock, showing the forms of two boulders, and the darker-green rock separating them.

No. 1511 contains amygdaloidal portions of some of the boulders, showing the tubes perpendicular to the surface, one specimen having a glaciated surface. (Compare Plate 1, Sixteenth Annual report).

No. 1512 has chalcedonic silica from veins and spots in the rock 1510.

No. 1513. Vein matter in No. 1510, similar to 1501 which is from the so-called gold-quartz vein at Eagle Nest lake.

In returning from Ely to Tower the conglomeratic (or agglomeratic) character of the green stone was more frequently noticed at the occasional cuts. The rock is angularly and cuboidally jointed in most of the cuts, with a light green color, weathers lighter, but in some cuts it is a schist with a slaty tendency in disintegration, and has doubtless been called sericitic schist in many places.

Southward from Tower this rock continues, as seen from the train, as far as nearly to the gneiss exposures that appertain to the northern flank of the Giant's range. It has been reported by H. V. Winchell** that there is no exposure of mica schist between its last exposure and the first of the gneiss. There is an unobserved interval, however, between the two amounting to about two miles in which there may still be a narrow belt of mica schist.

[NOTE. In the spring of 1890 a belt of mica-hornblende schist was exposed in some railroad cuts, a few miles north of the Giant's range syenite.]

Pokegama Falls and eastward to Griffin's camp. At the falls of Pokegama the dip of the quartzyte was carefully measured at several points, with the following results: Below the falls, S. 8° W. about 15 degrees; above the falls, S. 8° E. about 15 degrees; at the bluff, on the west side of the river, a sixth of a mile above the falls, S. 22° E. 8 degrees.

The rock is quartzyte, red superficially (from six to twelve inches) and gray within. The bluff above mentioned is 27 feet high above the water, and the beds composing it seem to strike southeastward to the falls. Mr. Griffin says this rock runs under the river which is the outlet to Pokegama lake, and used to cause rapids at half a mile below the lake, in Sec. 23, T. 55-26. But now these rapids are covered by the setting back of the water into the lake from the Mississippi from the government dam, which is built just above the falls. He also says he thinks he saw once (as surveyor) an outcrop of it on Little Boy river, about in the line of strike from Pokegama falls. H. V. Winchell also reports having seen it on Little Boy river. Mr. Griffin also is authority for an outcrop of the same rock about eight miles southwest from Pokegama falls. In 1871 or 1872, as deputy surveyor, he also noted the same rock north from Sugar lake (two or three miles) in Sec. 6 or 31. This rock appears to be the Pewabic quartzyte, so named much further northeast on the southerly slopes of the Giant's range.

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*Fifteenth report, p. 325.

**Seventeenth report, p. 89.

October 18, 1888. In the rain (there was a drizzling rain all the rest of the day) we went to the falls of Prairie river, first seeing the granite at the upper falls.

There is a large display here of gray gneiss, some of it being micaceous, and some of it having hornblendic, dark masses and belts cutting through it. In some rare places it is laminated in thin indistinct laminæ of mica and feldspathic sheets. Its dark belts and isolated masses recall the rock at Morton, on the Minnesota river (see another section of this year's report) and north of Vermilion lake, but there being so little of this it will not be correct to parallelize it with the mica-hornblende series. It is rather the extension of the Giant's range rocks, which are mostly without noticeable micaceous or dark hornblende laminations, and generally a more massive rock than the micaceous gneisses of the Vermilion series. At one point on the west bank of the river there is a rude horizontal, undulating stratification or bedding. On the east bank opposite this, however, the gneiss is conspicuously basaltically jointed It is probable, therefore, that the former may be due to weathering upon a spot where by a shearing pressure a local lamination had been superinduced. There are also in some places in the gneiss, thin alternations with a shining micaceous schist running about horizontal, such that the general aspect and average composition is quite different from the rock in general (see No. 1523). Red orthoclastic belts (1524) more coarsely crystalline, containing also coarse quartz crystals, run irregularly through the mass. In one spot a wedge of reddish rock, associated with chlorite, making a (protogine?) runs through it.

We do not see the contract of this gneiss with the overlying quartzyte. The latter is seen at the lower falls and while dipping in the main to the s. s. e. about 10 degrees (sometimes 12 degrees) it undulates in one or two synclinals. Along the top of one of the anticlinals can be seen a distinct fracture, opening somewhat upward, as the crest runs across the river.

Glacial marks here run S 10° E. (mag.) and Mr. Griffin says there is no magnetic variation here.

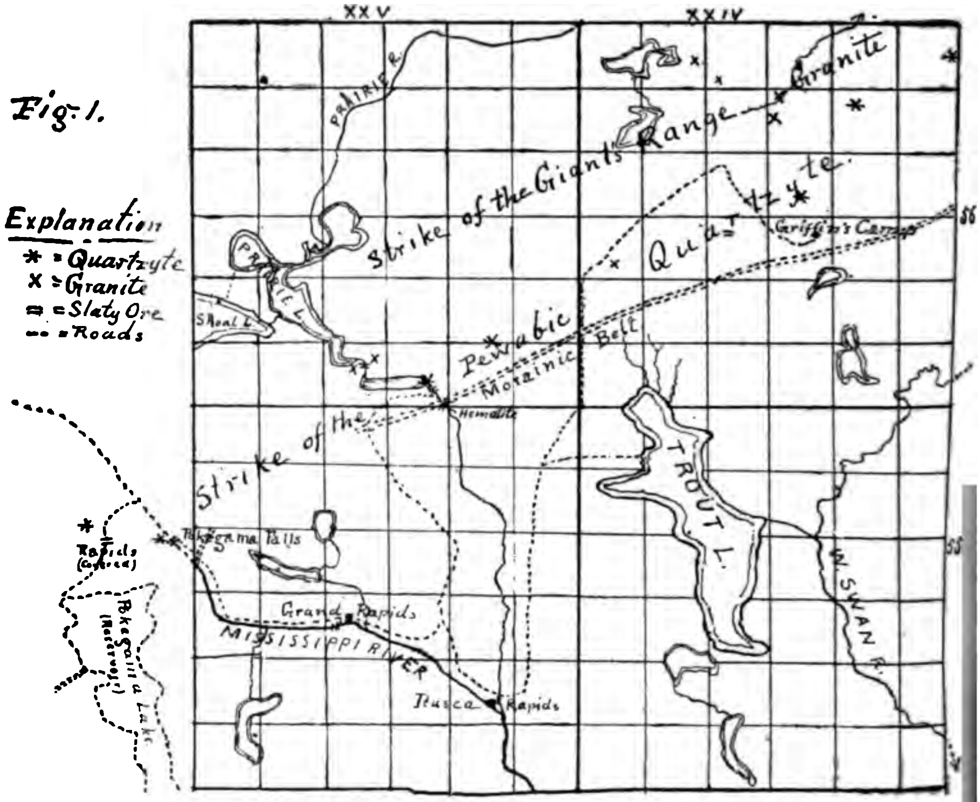
No. 1525 (a) represents an incipient or pseudo-amygdaloidal spottedness in this quartzyte, which may be allied to that lately described by Bailey at Pigeon Point.

No. 1526 shows another spottedness in this quartzyte, the rusty spots weathering out and making the surface pitted all over.

No. 1527. So far as can be seen then comes on toward the south (after an unexposed interval) a lot of siliceous and hematitic cherty beds, the hematite in some cases being fine, massive, nearly pure, and finely basaltically jointed. These beds are seen only about five feet in thickness, and the hematite is apparently not more than six inches. No. 1528 represents some of the rock about at the horizon of this hematite. No. 1529 somewhat above (in the beds). No. 1528. This shows a curious "streamed" mixture, and brecciated bed of chalcedonic silica, jasper and hematite, with vitreous glassy silica filling veins or former geodic elongated cavities that are embraced entirely in a casing of white chalcedonic silica. The highest part is represented by 1530, which has a very different aspect from 1529, being a coarser, evidently fragmental, rusty, siliceous, somewhat vesicular rock, but yet may be only a modified condition of 1529. It has pure hematitic sheets and lumps, and is, in general, bedded, and dips conformably with the quartzyte below, in beds fron six to ten inches thick. It is mainly a felsyte with hematite, some of the beds having the bloodstone distribution seen in some at the east end of Gunflint lake. Some of the quartzyte that underlies is conglomeritic (1532) in patches, but it is not seen so in any continued layers.

In making the trip from Grand Rapids to Griffin's camp (see sketch-map, fig. 1, p 16), we traveled eighteen miles over an execrable road in an autumn snow storm which not only kept our clothing wet but loaded every bush with dripping snow and water. As we had been in the rain the greater part of the previous day, and
g day in a snow storm of the same kind but
ve found the three days productive of results

Fig. 1.



The trip was very useful in a geological sense, but it cannot be said to have afforded sufficient evidence to answer the question of the true relation of the Pewabic quartzyte to the black slate of the Animikie. So far as the evidence goes, *unless there be two great quartzytes*, it seems to indicate that the Pewabic quartzyte overlies the black slate, although it is next in contact with or adjoining the granite all along the south side of the Giant's range and as far west as to Pokegama falls, at the latter place the quartzyte being separated from the gneiss by an unexposed interval of unknown strata, which is presumed to be occupied by the Animike slates proper. This evidence consists in the existence of the red soft shale (1533) above the quartzyte (1534), This shale is apparently the equivalent of the red shale which have been penetrated in some deep wells in the central part of the state and found to overlie the quartzyte (the New Ulm quartzyte), and also perhaps of the red shale seen at Black River Falls, Wisconsin, on the south side of the "Tilden mound," to which it bears a strong resemblance, making thus the it Black River Falls the 'alent of that in the Ani- (Huronian proper) in Min- a, to which in its lithology ;eneral character it has a resemblance, as well as in ɔar proximity to a corres- ing range of gneissic hills. .o confirms the opinion,else- ɘ expressed by the writer, ;he Gogebic ore is probably e beds which, on the south , represent the Animike of :orth shore, instead of the that contain the ore depos- Vermilion lake. The struc- ɪere is represented by fig- !, showing an ideal section .ng north and south at Grif- :amp. The horizon is there- ʳery near that of the works ıllmann, and of the mines › Gogebic region.

ere is yet one troublesome ɔlained fact, which does not ɪto place in accord with the :hat there is but one quartz- ɪd that it overlies the black unconformably, viz: The ɪines on the Gogebic range all to have an important ɪlar gray quartzyte under- them, and, according to all w, a black slate lying to the .of them and probably strat- hically above the ore beds, black slates being supposed › the Animike. If that zyte be the equivalent of the bic quartzyte it certainly below the iron horizon, and the Animikie iron, the sup- : equivalent of the Gogebic iron strata, should be sought

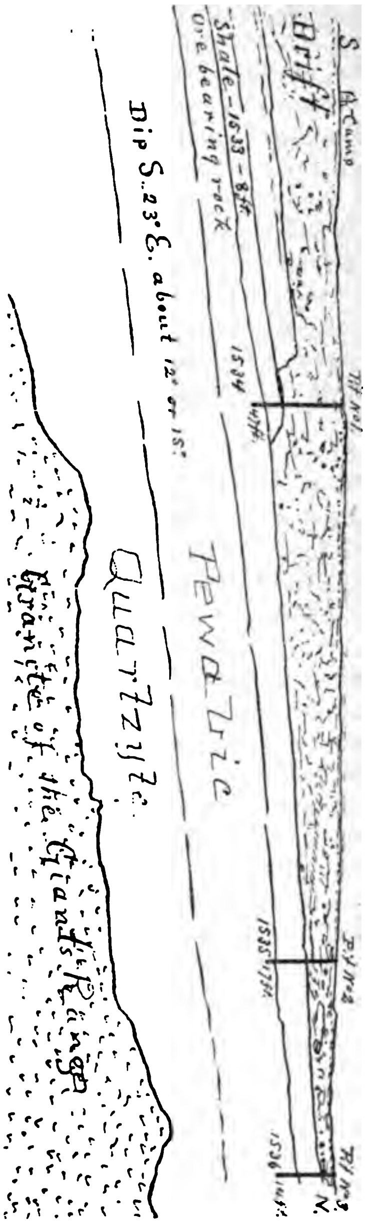


Fig. 2.

for toward the south from the strike of the Pewabic quartzyte in Minnesota. As there are outcrops of slates and quartzytes, of the Animike series, along south from the strike of the Pewabic quartzyte it is also legitimate to infer in the absence of facts demonstrating to the contrary, that in Minnesota also the main mass of the Animikie, and hence also the horizon of the Gogebic ore, lies conformably above the Pewabic quartzyte, and may be found to the south of the strike of the quartzyte. In all the reports and inferences that have been published by the writer the Pewabic quartzyte has been made the parallel of the great quartzyte that overlies the Animikie unconformably, but it is possible that it runs below it conformably. Its age in either case is that of the great gabbro flood, with which it is interbedded at points further northeast.

Specimens from Griffin's camp, ne¼, sec. 22, 56-24, No. 1533, red shale, 8 feet; No. 1534, iron bearing rock, somewhat siliceous, ore-sheets broken and irregular, hematite; No. 1535, same as 1534, pit No. 2. but reached at 15 feet below the surface; No. 1536, same as 1534, 11 feet below the surface. No. 1537, slaty ore, rather low grade, (47 p. c.) nw¼, nw¼, sec. 21, 56-24. Mr. Griffin says that in sec. 21 he knows that the rock 1537, lies to the south from the rock 1535 and 1536, in outcrop in the same section. He also says that at three or four miles south from his camp fragments of black slate are abundant in the drift, indicating black slate lying above the rock seen at his camp.

Where the road crosses the morainic belt (see the sketch map, Fig. 1,) between towns XXIV and XXV, the hills are very conspicuous. It appears that the morainic belt coincides, in general, with the strike of the quartzyte, a fact which has been noticed before in Minnesota (and in Ohio, in case of a strike of the limestone as in Delaware county), and it is very likely that the existence of the latter had a powerful influence in determining the southward limit of the drift-laden ice.

That this range of iron ore is independent of and quite different from that at Vermilion lake, which is in the Keewatin schists, is shown, not only by the general geology and geography, and the difference in the manner of occurrence, as well as in the ores themselves, but by the fact that the line of strike of the Keewatin ore belt from Tower westward is found to cross the country about thirty miles further north. It has been discovered at several points, where it affords very encouraging outcrops, and samples of first-class magnetite have been exhibited by those who have visited the region. Mr. John Beckfelt, postmaster at Grand

Rapids,[**] has manifested an intelligent interest in this more northern iron region, and from the samples in his possession the following were obtained: No. 1538, magnetic iron ore, sec. 23, 60, 23; No. 1539, rock associated with 1538. This is magnetic and siliceous, black, fine grained, apparently a magnetic jaspilyte.[*] This is described as standing vertical in the midst of vertical green schists. Charles Kearney, Grand Rapids, owns an iron location on sec. 27, 60-23, and — Fleck on sec. 23, 60-23; other owners are reported to be Lawrence Welsh, James Gill, Eli Signal, William Wynn, Al. Tory, J. H. Hennessy and — Knutson.

According to Mr. Griffin, there is an outcrop of "granite" at a point about ten miles south of Leech lake, the exact position of which he could not give. This indicates the strike of the Giant's range granite.

Gold in the Keewatin schists in northern Minnesota. It is well known that about twenty years ago, a gold excitement sprung up in Minnesota, centering on Vermilion lake.[†] Mr. H. H. Eames, the state geologist at that time, was largely instrumental in promoting the popular interest in that region, and in the reputed discovery of gold. The excitement subsided soon, and ever since then there has been very little said on the subject. But it appears now that there was some basis of fact underlying the excitement, and that possibly in the future the interest that subsided in 1866 may be partially revived. Several assays of auriferous quartz were published by Mr. Eames in his reports, some performed by J. R. Eckfelt, assayer of the U. S. mint at Philadelphia, others by professor E. Dent, New York, and by himself, which afforded gold amounting from twenty to thirty dollars per ton of the ore, with three or four dollars per ton of silver. This came from some of the workings about Vermilion lake.

In 1887, the writer visited the Marquette iron region in Michigan, and the Ropes gold mine northwest from Ishpeming.[‖] He was at once impressed with the resemblance between the gold-bearing rocks seen all the way between Deer lake, near Ishpeming, and the Ropes mine and the rocks of the Keewatin, in northern Minnesota,[‡] and in all subsequent study, involving this question, he has placed the two localities provisionally in the same stratigraphic position. This parallelism at once recalled the early reports of finding gold at Vermilion lake, and aroused a suspicion that gold would be proved to exist in the quartz leads in the Keewatin, in Minnesota.

[**] Mr. Beckfelt also showed samples of lignite found "up the Mississippi river," say about Winnibigoshish lake. He also says it is reported to be found all about the shores of lake Winnibigoshish, in form of "float" pieces. He also states that he has seen pieces found "up the Prairie river."

[*] The occurrence of magnetic ore in the Keewatin, near Ely, as well as at Tower, is described in Bulletin No. 6.

[†] Compare the report of H. H. Eames on "The metalliferous region bordering on lake Superior," printed in 1866.

[‖] Sixteenth annual report, pp. 48-49.

[‡] Seventeenth *annual report, pp. 42-43.*

In 1878, this region came again under examination by the state survey in a rapid reconnoissance, made by the writer, along the international boundary to Vermilion lake, and thence to the St. Louis river, and the principal "locations" were visited. The small specimens collected from the dump heaps were as large as the means of transportation would permit, and of course feebly illustrate what may have been the contents of the veins that were explored by the various owners in 1866. The samples are numbered 395–400, and 423, 428.[*]

Prof. A. H. Chester again examined these gold-mining locations, and states in his report that "Specimens were collected from many quartz veins, on some of which mines were formerly located, and all were carefully assayed. No true iron pyrites was found, but all was of that form known as pyrohotine or magnetic pyrites. Among the many samples of pyrites, from all parts of the country, assayed for gold at the laboratory of Hamilton college, not one containing magnetic pyrites has shown any gold, and so-called gold mines have been condemned at once when the character of the pyrites was recognized, subsequent assay always corroborating the opinion. It was, therefore, not a matter of surprise that these 'gold ores' did not contain any gold."[‡]

In 1886 Dr. A. Winchell examined the town in which is situated a prominent white quartz vein in which it was reported gold and silver had been found, and his collected samples at this point are numbered (of his series) 48-53.[**] He says: "Many quartz veins run through the whole formation. Rock 52 is a sample, containing hematitic stains, very much, indeed, as in some argentiferous[auriferous?] quartz. Other quartz veins are pervaded by pyrites in abundance, as shown in rock 53. In some cases a mass half the size of one's head is pure pyrites. The pyrites and quartz are sometimes seen to be intersected by minute, sinuous veins of a dark, lustrous iridescent mineral resembling peacock ore of copper. These are the glittering minerals which sustained, not without some reason, the hopes of the adventurers." At that time this spot was owned by a man, since deceased, named John Leienderker, who had sunk a shallow shaft in 1885.

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[*] Ninth annual report, pp. 98-103.

[‡] Eleventh annual report, p. 166.

[**] Fifteenth report, p. 32.

In 1888, in making some observations on the iron working of John Mallmann, about two miles south of the Giant's range, as reported above, the writer met Mr. Leienderker at Mallman's camp, and obtained from him a small piece of the quartz containing pyrites from his "gold mine" on Eagle Nest lake. Sec. 34, T. 62-14.

Some assays have since been made, viz:

Samples of pyritiferous quartz obtained by A. Winchell, from Leienderker's shaft, with the following result, assayed by Frank C. Smith, Ann Arbor, Mich.

A. Winchell's numbers 49 and 51, gave no trace of gold.

A. Winchell's number 53, gave one-twentieth of an ounce of gold per ton of 2,000 pounds, or $1.00 per ton.

Sample of pyritiferous quartz obtained by the writer from Mr. Leienderker; assayed by Prof. J. A. Dodge, Chem. Series, 212. Survey No. 1501. "Using one-half ounce of the ore, by fire assay, I find a trace of gold and no silver. The amount of gold is too small to be weighed from that quantity of ore; I should estimate it at not more than one-fortieth Troy ounce per ton."

All the samples from the various "locations" about Vermilion lake obtained by the writer in 1878, * assayed as one sample by Prof. C. F. Sidener, Chem. Series, 213, gave no gold nor silver.

The vein at Eagle Nest lake is said to be about 12 feet wide and to carry much pyrites throughout its width. The pyrite in the sample obtained from Mr. Leienderker is not magnetic in fine powder. It has a light brassy color and rectangular, apparently cuboidal, crystallization, which seem to indicate true pyrite. That which Prof. Chester examined was magnetic pyrite which is rarely if ever auriferous, and was at once condemned by him. There is a large amount of magnetic pyrite near the base of the Animike formation at the west end of Gunflint lake, associated with the magnetic ore of the Animike, which is of the same range and age as that investigated by Prof. Chester on the Mesabi range, and it is quite likely that the magnetic pyrite examined by him was obtained in that group of rocks. That has a different aspect and color from the pyrite at Eagle Nest lake, being a copper-steel gray, and also is much softer.

It appears from the foregoing considerations, and the facts that are known, that not only is there no *a priori* obstacle to the expectation of gold in the quartz leads of the Keewatin, but that there is some positive basis of fact to show that it exists there in quantity sufficient, in some †cases, to make a valuable low grade ore that could be profitably mined by the same methods as those employed in the Black Hills, and at the Ropes mine in Michigan.

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* Ninth annual report, pp. 98-103.

THE CRYSTALLINE ROCKS OF THE MINNESOTA VALLEY.

In June 1888 some observations were made about Redwood Falls. At Frazer's quarry, in Honner, (N. Redwood P. O.) which is on the south side of the Minnesota, but on the northwest side of the Redwood, in the bottom lands of the Minnesota river, can be seen gneiss, some of which is prevailingly red on weathered exposures, but on quarrying deeply—and some without being quarried—is gray. This rock is a gneiss, through and through, having a "rift" which is strongly marked, and generally evident in difference of colors and in micaceous belts, the alternations being black, quartzose, feldspathic, reddish, &c. There are some places that show up as a massive, gray gneiss, without much banding, but the whole rock is generally quite banded. Across these forms run granulyte veins, and coincident with the gneissic bands are other orthoclastic belts, some of them plainly fading out into the gray gneiss, and some being distinctly separate for many feet. These are either of chemical deposition entirely, (as when filling transverse fissures) or are produced by slow chemical metamorphism from the original sediments. In two instances one of these veins, about ¾ in. wide, running transverse to the grain of the gneiss, split in the center of the vein, and one-half of it adhered to one block, and the other to the other block, when forced by the operations of the mine. This splitting ran about six feet, and showed, when cleared off, a surface 16 in. by 6 ft., and at a distance I took it at first for a vein 16 in. wide because viewed from that direction. This vein matter was coarse red granulyte. Other similar veins when viewed on the broken edge showed a distinct *central plane of union* between the growing accumulations on the opposite side f the original fissure, just as in common mineral veins, thus: Fig. . Such a plane would be a plane of weakness, along which in uarrying, the rock would be likely to part.

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†Capt. Gibbons, in test-pitting for iron in 63-11, is reported to have found a nugget of gold valued at about four dollars, and Mr. J. G. Emery affirms that in the quartz veins in the greenstone on the southern slope of the Twin peaks south of Ogishkemuncie lake he has very frequently obtained gold. It might also here be recorded that according to Mr. Emery, who showed me a sample, a finely granular graphite occurs on lot 9, se ¼ sec. 18, 64-6, (east of Frazer lake). He describes it as surrounded and overlain by gabbro. At a mile further west, and a little north, it shows on the surface in a vein ten feet wide; and pieces as large as a half bushel lie about, as if thrown out by the frost. It is also found on the portage trail a little north of the trail) from the east end of Frazer lake to the lake next toward the southeast. Considerable iron ore is reported by him in the greenstone, in the north parts of secs. 2 and 3, 64-6, i. e., in the region of the Twin mountains.

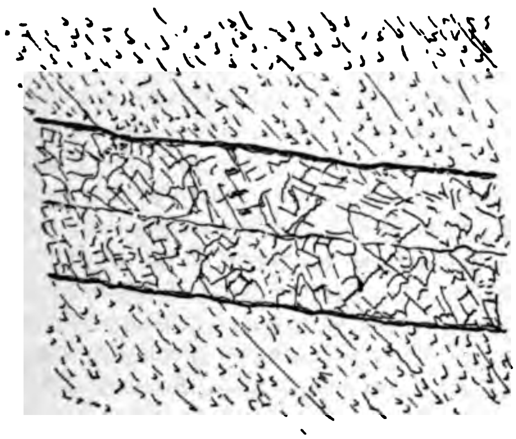

Fig. 3. Layered vein of Granulyte.

At Morton, a few miles below Redwood Falls, situated in the valley of the Minnesota river, Saulspaugh has recently opened extensive quarries in the "granite." Here the rock is mainly a gray contorted gneiss, but it has, in all the usual forms, much reddish feldspar supposed to be othoclase. Veins of granulyte ut the gneissic structure. One was 14 inches wide and was banded n the same manner as illustrated by fig. 3 above, except that its ourse was nearly perpendicular to the gneissic rift, and it showed, urther, a banded alternation of quartz and feldspar, as illustrated y fig. 4 sketched on the spot.

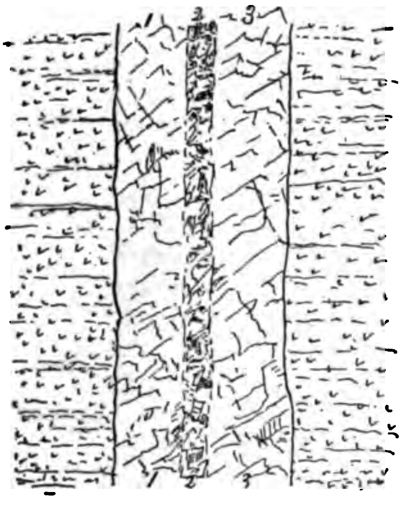

Fig. 4. Vein of Banded Granulyte and Amethystine Quartz.

Explanation of Fig. 4.

No. 1. Coarse orthoclase, with little quartz.

No. 2. Coarse crystalsof quartz, somewhat amethystine.

No. 3. Same as No. 1.

This shows a true vein structure, and a chemical origin for the "dyke." The figure shows the planes separating the quartz from the orthoclaserather more abrupt and straight than they are in nature. Along the line of contact some of the orthoclase crystals penetrate within the quartz zone, and there are a few quartz crystals disseminated through the orthoclase. But, as a whole, the central band of amethystine quartz is distinct and constant.

Another remarkable feature in the Morton quarries, where there has been more work done than in any other granite quarries in the state, and from which they have sent rock for street curbing to Duluth, is the beautiful contortion of the gneissic structure, which on being broken, and especially when cut-hammered, makes a striping resembling that seen on some fancy marbles.

And yet another feature, which allies this belt with the transition series at the northwest end of Vermilion lake, is the irregular mixing of the "mica schist," or "black rock," with the gneissic lighter-colored rock. These so-called mica schists appear as isolated masses, one as large as ten feet across, but usually only a few inches in diameter, like boulders in the midst of the gneiss. In one conspicuous instance, seen on a freshly cut block of gneiss, the laminations of the gneiss were seen to shape themselves about the black mass. In many other instances the black patches are changed in shape, apparently by some shearing pressure incident to the whole formation. They are elongated and bent and strung out like hooks and lenticular bands, in conformity with the direction of the general trends of the gneissic contortions.

While these black patches appear (now) to be largely micaceous and of the same nature as the micaceous element in the gneiss, yet there is noticeable a difference. They seem to be of changed hornblende or hornblendic rock (1519.) The "black rock" in one limited space was seen to comprise at least half of the whole, and it seemed to be the same ingredient as the black element in the gneiss—at least so far as its distribution and relations could be seen to show anything of its origin. This "black rock" should not be confounded with another "black rock" which in the form of a conspicuous more recent dyke cuts across the hill composed of gneiss.

The general similarity of this quarry to the mixed condition of the mica schist and syenite in the northwest part of Vermilion lake, where the Vermilion series fades out into the gneiss proper, of the Laurentian, is forcibly impressed on the mind of any one who is familiar with the latter. The transition in the Minnesota valley, however, seems to occupy a wide belt, as it extends at least from Redwood to Morton—and indeed to occupy nearly the whole valley.

In town 111-38 (unorganized), of Redwood county, sec. 12, is a glaciated granite knob, the striæ running S. about 45° E. This is a dome of gray contorted gneiss, rising about twelve feet. Its [illegible] extent is about 200 feet, and 90 feet across. Its elongation [illegible] and SE. It is a good rock for heavy quarrying, as it is not much jointed. It is heavily bedded by a series of overlying layers that dip gently toward the south, so that the steep side of the knob is on the north slope. The country round about it is wild, unoccupied prairie, smoothly rolling.

This rock shows no red feldspar, in that respect being somewhat more like the Honner quarry than the gneiss at Morton. The top is somewhat below the average level of the country, and has been uncovered by the removal, by some means, of the drift cover. The field can be plowed right up to the rock on all sides.—Sample 1520.

In making this trip a new sort of boulder was seen in many places—a white granular quartzyte, some of them two feet across. They show a plain sedimentary structure, and are rather fine-grained. They are hauled with other boulders into piles from the fields. They look like the usual "Winnipeg" limestone, of which not a piece was observed on the trip, although they do occur about the mouth of Crow creek.

Re-examination of Lignitic beds about Redwood Falls. In company with Mr. Park Worden, Capt. Dunnington and Mr. Terrill, of Redwood Falls, a number of workings in lignite beds in the vicinity were examined, particularly in the region of the valley of Crow creek. One of these was the very spot that I visited 15 years ago, now caved in, and nearly lost to sight. Another was visited with Mr. Peabody at the identical spot where Grant and Brousseau tried to get coal about 20 years before. None of these reveal anything new, nor give any reason to vary from the judgment and descriptions published in the second annual report, respecting their geological age and prospective economic value.

At Mr. Farrington's, on the bluff of the Minnesota near Crow creek, the lignite lies on the decayed gneiss, or on a somewhat stratified and re-arranged condition of it, due to the Cretaceous ocean. There is no conglomerate at the bottom--only this kaolinic material.

III.

RECORD OF SOME FIELD OBSERVATIONS MADE IN 1889.

Duluth. On the "Weller road," about a mile and a half from lake Superior (at Duluth) and about two miles, by the road, from the business part of the city, is the spot that has been referred to *before as showing considerable amounts of red rock in the hills.

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*Survey samples of N. H. Winchell, Nos. 1B. 46.

Compare also Proceedings of the American Association for the Advancement of Science. 1881. Cincinnati meeting. *Typical thin sections of the Cupriferous rocks in Minn*

There is not so much of it as I had thought. It is very certainly the same rock, and has the same relation to the gabbro as that seen at Duluth and mingled with the gabbro at Rice's point. It is here in a scattered blotch, and in thin veins, in a fine porphyritic, gabbroloid rock—which last is like much seen in the city and environs of Duluth, but not so perfectly and coarsely crystalline as the Rice point rock. While the gabbro is quite different from the typical gabbro at Rice's point, it is essentially the same rock and of about the same age. Indeed it is almost possible to trace it continuously from one place to the other along the hill range that connects the two places. No. 1540 shows the gray porphyritic gabbro with a fine magma. No. 1541 shows contact of the red rock on the gray rock, 1540. No. 1542 is the crystalline red rock, with some light green spots. No. 1543 is chalcedonic quartz from this gabbro, as described below.

A very interesting observation is made in connection with this modified gabbro. On the weathered surface, where it also presents other irregularities of structure, resembling coarse amygdaloid, are seen white spots of silica. These spots are sometimes vitreous and glistening, as if of chemically deposited quartz, and in some central cavities quartz crystals form a drusy coating. But in other places this pure vitreous white quartz becomes granular, there being a gradual passage from one structure to the other, the granular increasing in distinctness and ease of disintegration toward a weathered angle, or toward the surface. Very rarely, small, subtranslucent areas as large as a wheat grain, or larger, can be seen, on the disintegration of the vitreous portions, which do not disintegrate, resembling amorphous or chalcedonic silica. The disintegrated granular portions, however, are not uniformly fine, and, in general, those portions are all coarser than the fine granular silica of the so-called chalcedonic silica of the iron mines. This observation shows:—*That the granular structure seen in silica, does not prove necessarily that the silica was of sedimentary or clastic origin*, since this is plainly the result of long weathering of chemical selica in these exposed cliffs.

These quartz masses do not show plainly a banded agate-like structure like the agates seen at Agate bay, or Gooseberry river, but in some of them there is a narrow band of harder, somewhat reddish, siliceous rock that surrounds them and forms an enclosing ridge that rises above the general surface. They vary in size from a pea to eight inches long, and while not very sharply angular, are not of the shapes of usual amygdules. Some of them have little cavities of irregular shapes in which small quartz crystals are seen projecting, and in others the white vitreous quartz is replaced, in marginal patches, or even in larger table-like protrusions, by a milky, opaque quartz, as mentioned above. Taken altogether it seems very likely that these quartz modules are indigenous in this gabbro-like rock, and are not of the nature of foreign or transported masses, but have originated in the gabbro by secretion, in a manner similar to the chalcedonic agates in the trap at the mouth of Gooseberry river (519).

At the Iron Mines at Tower. The designations of the various "mines" have been changed since the ownership changed. They are now known by number, viz:

No. 1 is what was known, and designated in our former reports as the Stuntz mine. It is the most easterly of those on the southern slope of the "north range."

No. 2 is what was formerly known as East Stone mine.
No. 3 is what was formerly known as Stone mine.
No. 4 is what was formerly known as Stone mine.
No. 5 is what was formerly known as East Ely mine.
No. 6 is what was formerly known as West Ely mine.
No. 7 is a pit on the former Tower mine.
No. 8 is what was formerly known as the East Tower mine.
No. 9 is what was formerly known as the West Tower mine.
No. 10 is what was formerly known as the Lee mine.
No. 11 is what was formerly known as the East Lee mine.
No. 12 is what was formerly included in the Breitung mine.
No. 13 is what was formerly included in the West Breitung mine.

Under the direction of Mr. H. A. Wilcox a systematic probing of the region has been carried on by diamond drill. This has resulted in the discovery of the existence of ore in some places not known before, and particularly near Tower in the "south ridge" or Lee mine. Some of the particulars of this drilling have been supplied to the survey. Indeed, through the courtesy of Mr. Geo. C. Stone, and of Supt. Bacon, every part of the mine, and all the records whether of drilling, assaying, mapping, shipping and grading, pertaining to the operation of the company, were thrown open to the writer for the use that might be wished for the purposes of the survey. Much assistance was afforded in making this re-examination, by the co-operation of the officers and the mining captains of the Minnesota Iron Company, and especially by the records of the drilling and some chemical analyses, the former by Mr. H. A. Wilcox and the latter by — Waters. Most of this detailed information is to be found in the special report on the iron ores of the state—

Bulletin No. 6, accompanying this report, but published separately. Subsequently the same courtesy was extended to the survey by the superintendent and other officers of the mines at Ely.

The purpose of this more detailed re-survey was to arrive, as nearly as might be, at a final conclusion, based on facts observed in the field, touching the question of the origin of the iron ore; and while that was a primary purpose, it was intended also to obtain more details of the actual manner of occurrence of the ores, the operation of the mines, and all the statistics that would be needed in making a full presentation of the iron ores in published form.

These observations were made in company with, and by the assistance of Mr. Horace V. Winchell who had previously examined many iron localities in the state, and had been exclusively at work on the iron deposits for about a year, and who was familiar with all the theories that had been proposed, and the obstacles that they met with. We subsequently published in *The American Geologist*,* a summary and preliminary statement of the probable result of the investigation, so far as it related to the origin of the ore itself, and the same view is presented again, more fully, with many facts that sustain it, in another part of this report.

At this place but little more will be given than the connected thread of successive field observation, with references to the illustrative rock samples, and some of the steps in the argument.

At the Lee mine, rock sample 1546. Here we collected some of the quartz crystals lining vugs in the dense hematite. These have not the clouded "chalcedonic" appearance of crystals formed rapidly, or of rapid chemical accumulation without crystalization, such as seen in the quartz in the jaspilyte. This kind of quartz in the ores of the district has frequently been described in the reports, and it has been supposed to have had a later origin than the jaspilitic quartz.

In the dump at the Lee mine (No. 10 as above,) is seen a reddish, earthy-looking jaspilyte, beautifully streaked as with sedimentary banding—No. 1547. It contains much pyrites, which is in bands and streaks coincident with the banding, this being apparently the form taken by the ore when accumulated under circumstances that gave the jaspilyte this earthy character. While this pyrite is disseminated minutely through the whole of this, yet in larger quantity it frequents certain bands. It is noticed that these bands cease abruptly along one side, when viewed on the

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*American Geologist, vol. iv, p. 291. *On a possible chemical origin of the iron ore of the Keewatin in Minnesota.*

broken edge of the sedimentation, as if the conditions allowing its formation were wholly and suddenly changed in that direction. But on the other margin the pyritiferous bands fade out gradually in the midst of the other rock. This is the first instance in which any such variation, indicating an upper and a lower side to the jaspilyte in the process of formation, has been observed. It is probable that the line along which the abrupt change is introduced was the lower side of the pyrite band, and if the position of this impure jaspilyte within the mine, with respect to the strike of the ore mass, could be ascertained, it would furnish a key to the stratigraphic order of super-position of strata of the region–a desideratum which has not yet been supplied by actual observation, though it has been hypothetically deduced from a general view of the whole region. The principal pyritic streaks are about a quarter of an inch apart, but there are intermediate variations that also produce streaks, and on one side of the specimen collected the principal streaks are about three quarters of an inch apart, and somewhat undulating.

In other pieces this impure streaked jaspilyte appears as a pyritiferous impure hematite, and in others, still, the pyritiferous character is generally disseminated in the breccia of hematite and earthy jaspilyte. In larger cubes the pyrites is seen in a sort of soft greenstone.

1548. Breccia, a somewhat stratiform mass of fine pieces of red jasper, hematite, jaspilyte, quartz.

1549. Crystals that seem to be chalcopyrite, colored sometimes blue like erubescite (?) or bornite, Lee mine.

[On further examination these blue crystalline grains seem to be hematite tarnished.]

1550. Finely banded, whitish jaspilyte, part of a breccia, Lee mine.

1551. Hard hematite, with conspicuous included crystalline masses that appear to be chalcopyrite.

Going in the pit of the Lee mine, which is now 100 feet in depth, under the direction of the foreman (because we inquired as to the place of rock No. 1547 in the mine), we find the succession across the Lee mine to be as follows:

In fig. 5, which is an outline plan of No. 10, formerly known as the Lee mine, the star (*) indicates where the bedded rock, No. 1547, was found. Next north of it is breccia, with green stone material, with considerable pyrite and with the well-known white kaolinic, white substance. In the kaolinic material are ser-

icitic, but rather hard and coarse-grained pebbles. There is an abrupt transition from fine, hard hematite to the rock 1547, but the contact, which can, with some difficulty, be traced out on the face of the wall, is tortuous and oblique. In the kaolinic material are also rounded pebbles of No. 1547. The general order of succession, across the mine, is thus, from north to south.

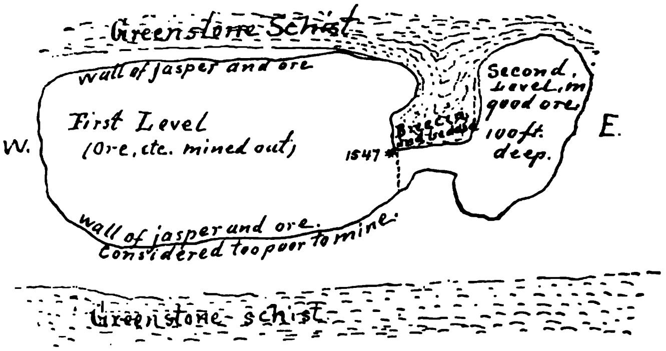


Fig. 5. Outline plan of the Lee mine.

1. Greenstone of the country, a chloritic schist, north side of the mine.
2. Breccia of greenstone, impure jaspilyte (rock 1547) and iron ore, with much pyrite.
3. Red, impure, sedimentary banded jaspilyte, somewhat resembling, in some places, a red shale, though it is always too hard and too heavy to be called shale. It is different from the well-known jaspilyte, as it shows no distinct chalcedonic silica, and only occasionally any distinct lines of hematite. It is not an important deposit, as to its amount, but apparently quite so as to its nature and origin, and its possible relation to the pure jaspilyte.
4. Fine, hard hematite, pure.
5. Main mass of ore; at its narrowest place about five feet wide, at the present face of the slope.
6. Jaspilyte, too poor to mine.
7. Greenstone schist, on the south side of the mine.

It seems as if the succession of formation progressed from the south to the north (or from No. 7 to No. 1), the impure jasper, No. 3 (or red shale) being formed by wash from No. 4, but rendered soft and impure by influx of materials from No. 7, or some other adjacent greenstone, and accumulated only in favorable nooks, followed by another greenstone (or schist), the latter serving, not only to break up and embrace in form of a breccia all the foregoing (Nos. 7 to 3), some of the inclusions being from the impure jaspilyte, some from the iron ore, and some from the jasper further south—but to contravene all the forces, whatever they were, that deposited the jaspilyte, and to substitute its own products entirely, with little or no modification, for the hematite and silica that had been deposited immediately before. If this schist (No. 1) were an undoubted, massive, homogeneous, non-clastic rock, it would be necessary to infer that the jaspilyte had been covered by a diabase overflow, and that in the bottom of the lava the materials of all the former strata had been involved in a brecciated condition. The occurrence of this breccia on the north side of the main jaspilyte mass, however, is not conclusive evidence of the later date of the origin of the northern side of the Lee mine, since there are jaspilyte masses in the green schist further north still, and some of them, when they were entire and continuous in one mass, may have supplied the material for the breccia, allowing the order of formation to have been from north to south.

Not far from Lee mine, by the old roadside leading to the Breitung mine and to the "location," on the top of the main hill, a large boulder was found of the Stuntz conglomerate, and its examination afforded some interesting facts.

1. This boulder contains pebbles of chalcedonic quartz (1552), some of them being several inches across.

2. It contains pebbles of gray, quartzose felsyte (1553 and 1554).

3. In these felsyte pebbles, which themselves are older than the boulder in which they are embraced, are rounded vitreous quartz pebbles which do not indicate any granular structure like the so-called chalcedonic silica.

4. Some of the pebbles of 1553, represented also by 1556, seem to exhibit an imperfect porphyritic structure, approaching that of "porphyrel" at Kekekebic lake, which they also resemble in nearly all other respects. This may point to some relationship between the Keewatin schists represented by the Stuntz conglomerate, and the porphyrel. The rocks, however, need a closer comparison.

The important result of this observation, however, is in the bearing it has on the nature of the granular structure of the jaspilitic silica. It has been presumed by some that the jaspilitic silica is granulated because of incipient decay, in the manner that the geodic silica in the gabbro near Duluth becomes granular. Not to mention here the evident difference between the granulation that is due to decay and that which is seen in the chalcedonic silica of the iron mines, it is sufficient to call attention to the perfectly intact vitreous condition of the quartz *pebbles within the pebbles* in this boulder, even when by fracture they have been brought to the surface of the boulder, and the perfectly characteristic chalcedonic granulation seen in the younger pebble of jaspilitic silica, No.

1552 above. That which is non-granular in this boulder is necessarily older, and has suffered more revolution of physical exposure, than that which is granular, for it is embraced within a smaller pebble, whereas the granular-silica pebbles are not so embraced. The granular silica pebbles are of the age (so far as respects the formation of this boulder) of the gray quartzose felsyte which incloses the non-granular silica pebbles. The inference is inevitable that it cannot be exposure and incipient decay which causes the granular condition of the jaspilitic silica.

We visited again the place that has been so many times referred to south of the Stone mine (pits Nos. 2 and 3) where,at the railroad cut, there is such a curious mingling of the green schist of the region with jaspilyte. I visited this cut with M. E. Wadsworth in 1886, to call his attention to the sedimentary interbedding of the schist and jaspilyte. There is a thin-leaved interstratification, and the jaspilyte is genuine, as such, not in "compound grains" as I had surmised. Cutting all this chalcedonic quartz are distinctly different veins of glassy quartz, of chemical origin, which has to be kept separate from the jaspilyte, some of them being six inches wide, and others not more than one-fourth of an inch—also geodic masses of the same.

Not only is the chalcedonic silica here interbedded, in lenticular sheets of the extent of one to three feet, (but frequently of less extent) but also there are small pieces disseminated through the schist, from the size of a pin-head to that of a man's fist, and also large masses having a red and purple color, placed somewhat irregularly in the schist.

There is also a siliceous base in the schist, which has this same chalcedonic grain, and some layers, (lenticular still) of a hard green rock, apparently more charged with this same silica.

As to this manner of occurrence of jaspilyte, I cannot make it consistent with any eruptive hypothesis—nor yet with sedimentary. The green schist is not here clearly of sedimentary structure, though there are variations in it to a more firm and siliceous character, that may be attributed to sedimentary accumulation. It appears to be best explained by supposing a combination of eruptive and aqueous agencies.

South of the Breitung opening, near the west end of the so-called "north ridge," runs a narrow streak of ore, about east and west, and since I saw it last it has been worked some. Westwardly it suddenly ceases, and a swampy patch supervenes, so far as can be seen in that direction. Toward the east it rises in the south slope of the main ridge, but as it is under drift deposits it cannot be traced but a short distance, and especially since where the work ceases in that direction it became rather narrow—say four feet, and seemed not to contain much ore. The structure of the green schists here dips northerly at 85° from the horizon, and the belt of iron and jasper oscillates in the schists on one and the other side of a right line.

This iron deposit is not first-class, but often pyritiferous, spongy and irregular, and apparently somewhat manganesic. The schists, at the spot where this belt crosses the road to the Breitung mine (No. 12), show a granular graywacke or sedimentary structure and origin, but not generally.

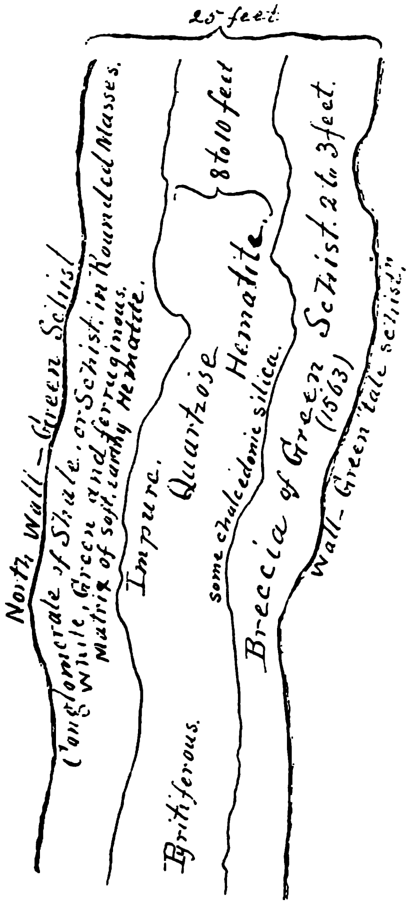

25 feet.
North Wall—Green Schist
Conglomerate of Shale, or Schist in Rounded Masses. White, Green and ferruginous. Matrix of soft, earthy Hematite.
Impure Quartzose Pyritiferous.
8 to 10 feet
Hematite.
some chalcedonic silica.
Breccia of Green Schist. 2 to 3 feet. (1563)
Wall—Green "talc schist."

Fig. No. 6.
North and south section across ore pit near the Breitung, in the narrow ore belt.

On inspecting the order of changes in the stratification across this narrow iron belt where exposed in the cut at the eastern end of one of these small pits, a north and south section is obtained.

The narrow ore-belt, a section of which is seen in figure six, is very largely "derived" from some other larger bed. It is not exactly like the regular jaspilyte ore of the north ridge, inasmuch as it is fragmental and consists of rounded masses of both jaspilyte and green schist. This is conspicuously so in the breccia on the southern side and in the conglomerate on the northern side. Through the central part of the ore itself there is considerable pyrites, and on the southern surface of the ore-streak can be seen some original jaspilitic silica, where the hematite is hard. There is in this ore-belt, besides, a considerable amount of limonite, some of it in botryoidal surfaces on quartz crystals, and on hematite (1564). The limonite sometimes is further covered with a thin blue coat, and in some cases, especially in the vicinity of pyrite, there is a surface of coxcomb crystals, like hematite, covered with black, which last possibly is manganese.

A little to the south of this opening is a shaft for hoisting from this pit. It seems to have encountered flinty, gray to dark gray, jaspilyte (1565) judging from a large number of fresh, large pieces that lie near in the dump, (=866 B). Compare 1277.

The principal Breitung opening is very irregular, the direction of strike of the main ore mass winding about in the green schist from east to west so as to run nearly north and south, and abruptly ceasing, or beginning where not expected. Three things are noticeable in conjunction with the ore.

1st. It is heavily jointed, about horizontally, but this jointed part is better ore, and lies below a less jointed mass of jaspilyte, the line between them being characterized by a rotted belt (1566), running diagonally across the face of the wall and descending toward the west. This belt where most rotted is a breccia, so that it is easily dug out even by the hand, and the part that disappears by rotting consists of angular jaspilyte masses. Several other beds of similar soft and rotted material are seen in the ore, sloping toward the west, some of them being lenticular. The occasion of this rotting is the existence of the joint, into which water enters at the top of the ridge where it comes to the surface. The joint cuts everything, rigidly, whether breccia or not, and the breccia is most disintegrated by the moisture and frost. This is evident because, while the rotted belt in the main follows the sloping joint, the rotted belt widens out when it approaches and cuts a breccia layer or mass, in the main rock, and in other places the beds of jaspilyte are preserved entire or mainly so (when not breccia) across the rotted layer.

2nd. The surface of the ore abuts immediately on the greenstone, and the two surfaces are mutually slickensided, the greenstone, in one instance at least, having a fine, curved, semi-basaltic structure which at the junction is nearly perpendicular to the surface of contact. But in other cases the schist is red and hard along the contact for some distance, say for twelve or sixteen inches, and is closely cross jointed and broken, rendering it fissile in small angular lumps.

3rd. In the remaining ridge, which separate the Breitung from the Tower, the firm jaspilyte of which it consists is seen to contain, in several places, and in one place in a somewhat continuous layer traceable, with some interruptions, twenty or more feet, a breccia and conglomerate, one inch to four inches wide, in which are small rounded, or sub-rounded, at least water worn, pebbles of vitreous quartz (1567). There are, on both sides of this band, and in many places over this immediate vicinity, spots of breccia of chalcedonic silica, cemented by smaller breccia and pebbles, as well as by massive chalcedonic silica, all of which consist of the well known chalcedonic silica. But in the above vitreous silica there is no such fine grain as that which characterizes the jaspilitic silica. On the hypothesis of decay and disintegration, as the cause of the granular condition, why is not this condition seen also in these rounded vitreous grains which must be older than the chalcedonic silica in which they are embraced? This observation, like that already detailed on the pebbles of a large boulder seen not far from the Lee mine, negatives all resort to such hypothesis. In this pebbly jaspilyte the vitreous quartz grains, although obvious, are distributed rather sparsely, and the whole space they occupy, forming an irregular and interrupted vanishing belt, or layer, near the center of the main mass, is not more than three or four inches wide, and is not a noticeable band.

North of the Tower mine (No. 8), on the north slope of the north ridge, is a conspicuous shoulder-like protrusion of hard ribbon-jasper, with characteristic undulating and contorted bands. This jasper has five or six thin layers of green schist, or siliceous green schist, running through it, which were cotemporary with the formation of the jasper, since they are flexed with the red and white bands. These layers enter on the eastern border of the exposure and continue zigzag across it, but some of them pinch out or fade out before they reach the eastern border. One of them, after such disappearance, rises again faintly a few inches further west between the same colored bands that enclosed it further east. Figure 7 was sketched from this jaspilyte surface, with the design to indicate the forms and alternations that are exhibited, but no drawing can show all the contortions, and transitions, and alternations. The shaded part is one of the green schist bands. On close inspection it is found to be considerably modified from the typical green schist of the country, having a liberal percentage of silica—indeed it is so siliceous that were it not for the contrast it presents with the smooth, hard jasper it would hardly

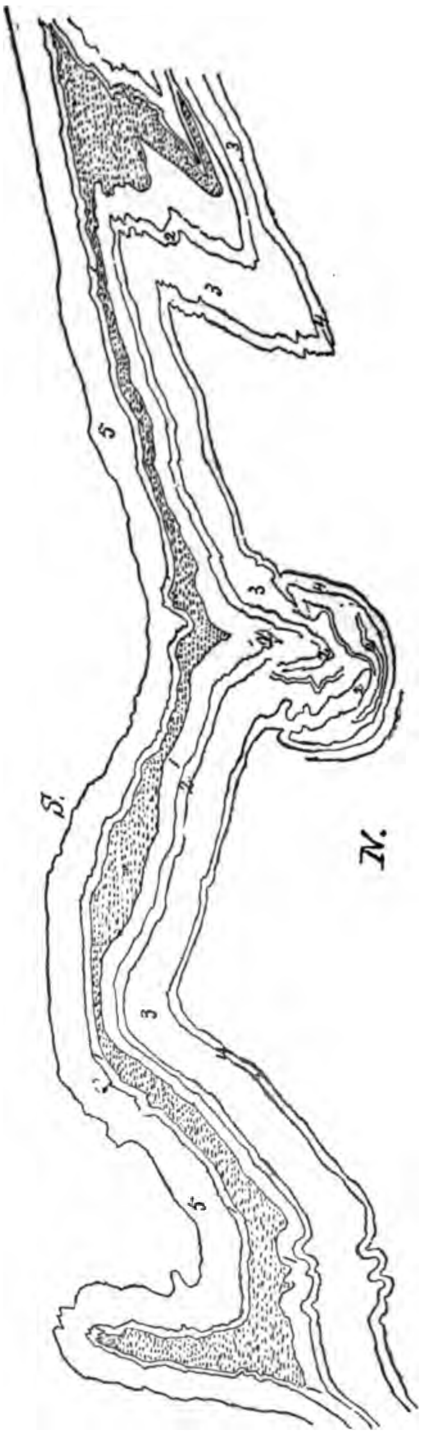


Fig. No. 7.—Green schist interbedded and contorted with the jasper ribbons.

be called green schist. Other belts of it, however, are less firm, and fade gradually into a softer (yet comparatively siliceous) light-green schist which cannot be mistaken for anything else than a part of the same rock as the green schist of the country. In case of all these green schist belts, though more siliceous than the average green schist of the country, they have disintegrated and been removed by the action of frost and vegetation, so that along their course across the jaspilyte knob, are little tortuous grooves due to their more rapid decay. A photograph was made of this jaspilyte surface, for which see bulletin No. 6.

In Fig. 7 the hooked expansion and sudden termination of the green schist band are in connection with, and a part of a general contortion in the jaspilyte which bends in the same direction, *i. e.* some of the thin layers do. The lamina of green schist in an attenuated condition runs from the end of the hook some further and squeezes out gradually, and is lost, the jaspilyte walls coming together, so far as the appearance shows on the glaciated surface. Beyond the keel of the hook, however, in the general course of direction of the band, the green schist band appears again, and continues as far as the uncovered condition of the surface will allow of its being traced. Here the contortion is in the form of a swelling and lifting toward the north. The beds next south run along without showing any sympathy with this irregularity. There is also a similar protrusion and contortion seen on the north side near the center of the sketch. On the south side here also the jasper ribbons are not disturbed. These contorted protrusions toward the north must have formed before the formation of the succeeding jasper bands in that direction, because, not only do they not participate in the contortion, but easily pass by the protrusions with gentle swells and flexures that are independent of the close crumpling.

The shaded part (Fig. 7) is a belt of green schist. No. 1. at the left is a thin scale of brown jasper. Toward the right further it is gradually replaced by a thin scale, and further still to the right by a narrow ribbon, of hematite. In this brown jasper are lenticules of crimson jasper, presenting a maculated handsome surface. It also shows the fine lamination one thirty-second part of an inch wide which has before been mentioned as a characteristic of the jaspilyte ribbons. It also embraces thin sheets of hematite, and it is cut and cemented by transverse veins of crystalline vitreous silica. No. 2 is mainly hematite, but it has threads (really sections of sheets) of brown jasper; and at the central swell it is rendered impure, being broken, spread, separated by brown jasper sheets, and occupies, with the jasper associated with it, the whole of the swell. No. 3 is a broad band of brown jasper, that also shows the crimson jasper already mentioned. No. 4 embraces a group of hematite sheets interleaved with jasper, too thin and too close to be separately traced. No. 5 is a band of hematite which, at the east end of the sketch is seen to be flexed southward so as to embrace and to coincide with the pot-hook direction of the green schist, but toward the west runs independently of the sharp north-side hook at the west end of the sketch.

The inevitable inferences from a study of this rock surface are: (1) that the two substances, the green schist and the siliceous jaspilyte and the hematite were the product of practically identical forces acting on different objects; (2) that after the formation of some of the narrow bands they were disrupted and contorted before the formation of the next succeeding bands; (3) that the southern side was the lower, and hence the older side, and that the growth was from the south to the north (as the beds now stand); and (4) that there was usually a complete cessation of the deposit of the siliceous jaspilyte when the materials of the green schist were accumulating, and *vice versa*, but that occasionally, as illustrated in these rather hard bands of green schist, the two substances were deposited simultaneously.

Any theory that will satisfactorily account for the origin of the Keewatin iron ores, must allow for these inferences from the physical structure at the same time that it plausibly accounts for the origination of the elements of which the jaspilyte and the green schist consist.

The fact that there was some force concerned that could fracture the last-laid-down layer without disturbing the deeper ones, and that it was remittent, so that succeeding layers were normally formed and were not fractured is demonstrated also by a sketch made here showing an interrupted layer of brown jasper, the separated parts being surrounded by hematite and embraced in a continuous schist of it, one of the integral bands of the jaspilyte, but themselves also seamed by crystalline silica at other points. See bulletin No. 6.

I am impressed with the indications that this silica is arranged by sedimentation. What was its origin?—probably chemically precipitated; perhaps also that of the St. Peter sandstone, although they are very different in respect to size of grain and in age. The eruptions of basic rock that characterized the Keewatin must have made such changes in the chemical conditions of the oceanic water that silica and hematite were thrown down. Can that be shown? Then came, if not the minute crumpling, at least the general tilting which has brought the beds to verticality.

It is well known that the first attempt to extract ore from these hills was made by George R. Stuntz and John Mallmann. Mr. Mallmann happened to be at Tower at the time this examination was being made, and he kindly pointed out the spot where this working was done, and we made a photograph of the same. It is near the Lee mine, on the south side of the "south ridge," not far west of the east opening (No. 11). By the blast one large lenticular mass weighing three or four tons was rent from the south side of the jasper bluff. The photo is intended to show this. In the hole excavated by the men and by the blast bushes have now grown up, but the course of the drill is still visible on the upper side of the dislodged mass. The photograph is reproduced in Bulletin No. 6.

In the highest of the tunnels of the Tower mine, which discharges southward, and also the most westerly, and at the southern end, is a north and south rock-cut which seems to trans-sect at a more western point, the rock to which I have so often referred at the railroad cutting immediately south of the Stone mine, about half a mile further east. The mixed and generally interleaved condition of the green schist and the jaspilyte is the same, but at this place, as the cut is across the structure more can be seen of the relations of the two rocks, viz.:

1. The jaspilyte is contained in the schist in lenticular masses, and in thin interleaved vanishing sheets that have their sharp edges upward and downward. This is most manifest, in innumerable instances here within the horizontal space of thirty feet.

2. The jaspilyte is contained in similar masses that terminate east and west in the schist.

3. In the space of 22 feet, north and south on the face of this cut, I count 36 jaspilyte layers, varying in thickness from ¼ inch to 24 inches, all of them having at least 6 inches extent up and down, the rest of the rock being green schist, or jaspilitic red schist (or "shale" similar to rock 1547). Besides these there are some indefinite graywacken layers containing rounded pieces of jaspilyte as pebbles.

4. On the east side of the cut is seen the manner of termination of one of the larger lenticules of jaspilyte, in the midst of the schist, the exposed terminal end appearing unbroken near the track, though broken off at the top by the work of making the cutting. The shape of this western termination is represented by figure 8, which shows a section across the lenticule north and south.

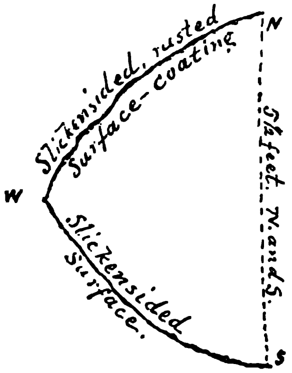


Fig. 8.
Western termination of a jaspilyte lenticule.

5. Within two inches of this large mass, sketched above, was a smaller, apparently concretionary mass of jaspilyte, about 18 inches in its greater (perpendicular) diameter, appearing on the face of the cut to be entirely surrounded by the green schist and separate from the larger lenticule. Desiring to know whether it was connected with the foregoing large mass, I had a crow-bar brought, and, on making some excavation about it, the smaller egg-shaped lenticule was dislodged entire and fell to the ground. It left a continuous concave socket, the exact imprint of itself, and was coated and smoothed over its whole exterior in the same manner as the larger one, and was wholly independent and

separate from it. It is numbered 1568. It is sharper, in cross section, at the upper end than at the lower, and while about 18 inches in perpendicular diameter it is four and one-half inches thick (n. and s.) and eight inches wide (*i. e.*, east and west). Several small parts, broken from the upper end before it was dislodged, are also given this number. This shows that the egg consists essentially of hard chalcedonic silica, with a little hematite.

6. Within the tunnel, toward the north further, the green schist contains graywacken bands. In these are small pebbles of chalcedonic silica, but, in 1569, can be seen three (½ in. thick) veins of chalcedonic silica crossing the structure of the green rock at oblique and varying angles. This was taken from the roof of the tunnel, about 15 feet from the southern entrance.

7. In No. 1568 the principal color-bands run across the face of the section, and are not wholly concentric. There is a series of accretionary bands, surrounding these and inclosing them with an outer rusty coating, which gives color to the supposition that the egg is wholly concretionary. These outside bands fade off into the green schist structurally and mineralogically.

8. The mass itself appears to have been a fragment dislodged from its native place, and, while perhaps not yet firmly rigid, to have been imbedded in the materials that now constitute the schist, and with them to have suffered the pressure and upheaval that have brought the beds into their present vertical position. If it had become rigid before it was placed in the schist, it might still, perhaps, have been compelled to take its ovate form by reason of pressure and the mechanical movements to which the beds have been subjected. Judging, however, from the general ovate form of all the jaspilitic lenticules, even the largest, it seems more reasonable to ascribe this shape to some forces or circumstances that attended its origination than to mechanical causes that operated afterward.

Revisiting the old pit of the Stone mine, and noting the so-called jaspilyte *dike*, illustrated in the 15th report (see p. 235), we observed another egg or jaspilyte similar to that just described, though this is partly disintegrated now so as to reveal an original brecciated structure, at least on one side. The harder part is perpendicularly banded jaspilyte. On its exterior is a layer of red shale about one and one-half inches in thickness. This egg is entirely isolated within the schist as shown by the following sketch, fig. 9, made on the spot.

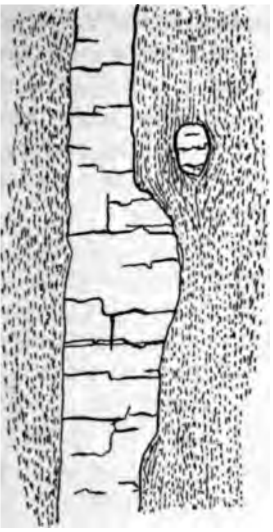
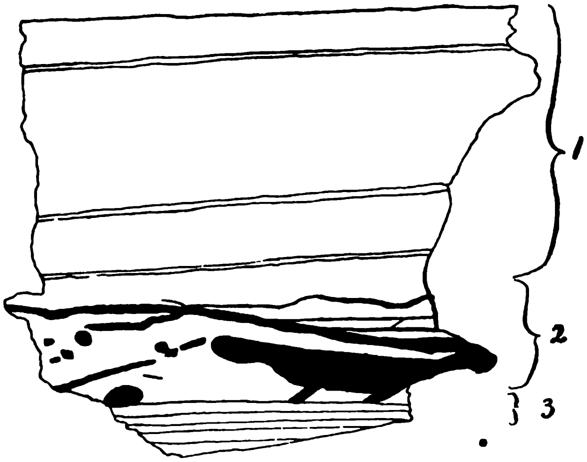


Fig. 9. Ovate lenticule of Japsilyte at the Stone mine, adjoining the "kike" of hematite.

A very interesting and instructive observation was made at the Stuntz mine, or No. 1. In some of the large angular pieces thrown out upon the dump is seen a singular sort of conglomerate and breccia. It is illustrated by the following sketch, likewise made on the spot, fig. 10.

In No. 1, by far the predominating ingredient is white, chalcedonic silica. The same is true of No. 3. No. 2 seems to have been suddenly introduced in the midst of a silica-forming epoch, and as suddenly to have ceased. This interruption caused the coarse fragmental transport of masses from some previously formed green schist and from the previously formed brown jaspilyte. The green schist pieces are somewhat rounded, as would be expected from their softer nature, but the brown jaspilyte pieces are angular.



Explanation of figure 10.

1. White chalcedonic silica, banded with a little pure hematite.
2. Conglomerate and breccia of green schist and brown jasper. The black parts show the shapes of the green schist pieces.
3. White silica and hematite.

This indicates some rupturing agent that acted on both rocks. Indeed, there are many evidences that a frequently recurring force, whatever it was, interrupted the quiet accumulation sometimes of the jaspilyte and sometimes of the schist, and tore up sometimes only the last laid-down thin layer, and sometimes larger thicknesses of the formed beds, and removed them to smaller or greater distances from their native places. This force acted in a common manner on both the acid jaspilyte and the basic schist.

There is hence much reason to suppose that all three of the known agencies for rock-forming were intermittently at work and concerned in the formation of the iron ore, viz.: *Eruption*, to afford the basic eruptive material; *sedimentation*, to arrange it (in the main), and *chemical precipitation* in the same water, to give the pure hematite and the chalcedonic silica. What was the cause of the chemical change in the waters of the Keewatin ocean that brought about the precipitation of silica and hematite, is matter for further research. An ocean, universal as the Keewatin formation, charged with silica in solution, a hot alkaline ocean, on the outburst of volcanoes, might, perhaps, be so far heated, and evaporated, as to be compelled to deposit silica as a chemical precipitate. On the other hand the introduction of cooler currents into the heated region would disturb the equilibrium of saturated solutions, and hematite (or limonite) might be the resultant precipitate. There is reason to believe the earthy, or semi-crystalline, schists of the age of the Keewatin are world-wide, and that, therefore, the ocean everywhere had, in general then, as now, nearly a constant character, only as modified by local or wide-spread volcanic agents.

By the railroad, just south of the Tower pits (Nos. 8 and 9), is a light greenish, novaculitic rock which dips N. 75 to 80 degrees (1557), It passes into graywacke. It is also highly siliceous with both chalcedonic and vitreous quartz, and has a fine white ingredient that gives it a feebly talcose feel, the last being the same element that we have called sericitic. The soft, light green (or white) mineral varies in amount from layer to layer, so that some of the sheets are smooth and soft throughout, and schistose, others being more like graywacke, and others almost a quartzyte in which the vitreous quartz grains can easily be distinguished from the chalcedonic, by their dark color, that is, by their absorption of light which falls upon their fractured surfaces.

I met Mr. W. G. La Rue, of Barraboo, Wis., and he gave me further evidence that there are really two quartzytes concerned, as already represented by me,* in the geology of the Gogebic iron region. One is that which is the foot-wall of the Colby and Aurora mines, and the other is that which Mr. La Rue describes, viz.: North from the Colby mine, near the bluffs of the gabbro range, which there are plainly visible rising as a series of hills within a mile or less of the village (Bessemer), he was employed to explore for ore by shafting for some parties who thought there was ore near the gabbro. He said that under the gabbro he found a quartzyte, and a sandstone, the two differing only in induration, one being more easily excavated than the other, both consisting of crystalline quartz. He shafted under the quartzyte in a conglomerate of iron ore, which seems to be comparable to that found in a similar situation at Ishpeming, Mich.,** and at Cascade near Negaunee, and after a time he found that the conglomerate turned almost at a right angle toward the north. He did not seem to know what was under the conglomerate, but he told me he found the quartzyte and sandstone together 235 feet thick. This was in the sw¼, ne¼ sec. 10, 47-46, Michigan. This is apparently the unconformable conglomerate and quartzyte that I noted at Bessemer, at the railroad, in a small exposure, in my sixteenth report.

IV.

THE AGE OF THE GABBRO.

In attempting to correlate these observations with those which have been made and recorded in previous years, there is some difficulty in fixing the stratigraphic place of the gabbro eruption. It was inferred by the Wisconsin geologists that the gabbro sheet was the bottom layer of the great Cupriferous formation, or Keweenawan, and this was accepted and has been followed unquestioningly by the writer in all previous reports and discussions of the crystalline rocks of the state. The age of the great Cupriferous formation, with its traps and conglomerates, in part at least, has been established, with increasing evidence and positiveness as on the horizon of the typical New York Potsdam—at least at the horizon of a quartzyte which overlies the Animike of the northwest.

Thus the gabbro sheet was carried to the same age. When the gabbro was found to be interbedded with a quartzyte in northeastern Minnesota, and to lie upon and overwhelm it, (the Pewabic quartzyte), it was a necessary inference that that quartzyte was the equivalent of the Potsdam—or at least of the bottom quartzyte of the Cupriferous—and hence must lie over the Animike, although at no place could the Animike be seen interposed between it and the gneisses of the Giant's range. When it was found that this quartzyte which is the principal iron horizon of the Mesabi range, shows evidence, in the region eastward from Pokegama falls, of passing below the body of the Animike strata, necessarily carrying with it the gabbro sheet, the idea that the gabbro has possibly been put into a wrong position is brought out prominently before the student of northwestern stratigraphy, and he is disposed to call in question the datum from which some important conclusions have been drawn.

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* See 16th Annual Report, pp. 55-6.

** See the 16th Annual Report, pp. 44-47.

The gabbro sheet itself is a wonderful formation, both in geographic extent, and in vertical thickness. It is also wonderful in the diversity of lithological variations that it displays—*i e*, when it approaches the characters of a normal doleryte, or when it is interstratified with beds of sedimentary origin, or when it is modified by contact with them. Yet its persistence under erosive and atmospheric agents, and its great volume, causes it to appear prominently and suddenly, and frequently, giving it the reputation of greater area and importance than it deserves. This is rendered more marked by the fact that its line of outcrop is characterized by heavy drift deposits which have covered up the less persistent formations and hid from inspection their true relations both to the overlying and underlying strata. It was hence a very natural conclusion that its advent was the opening scene of that succession of eruption and sedimentation which is displayed in the Cupriferous formation and that the whole should be grouped together under that single designation.

It is the design of this chapter to call attention to some facts that indicate that the gabbro lies below the Animike, (Huronian black slate), in great part, and that the later trap eruptions, continuing through the Animike and the Potsdam, (*i. e.*, the Huronian quartzyte), probably constitute the age and the strata of the Cupriferous formation—the "Keweenawan" of the Wisconsin geologists In other words it seems as if the Keweenawan series, in its full scope, embraces not only the age of the Huronian, (Potsdam), quartzyte, but also of the black slates of the Huronian that underlie the quartzyte.

1. The most important and significant fact that bears on the stratigraphic position of the gabbro, respecting its relation to the Animike black slates, is its occurrence along a wide extent, reaching from Gunflint lake southwestward as far as to the railroad

crossing at Mallmann's, (at least), *next to and immediately south* either of the gneiss of the Giant's range or of the "greenstones" of the Kawishiwin, without the appearance of any of the black slates between them. There is an appearance of *quartzyte*, with olivine grains and with magnetite, geographically between the gneiss and the gabbro, the same being unquestionably the Pewabic quartzyte seen near Gunflint lake. This quartzyte sometimes is impure and limonitic, and seems to be the chief iron horizon of the Mesabi range. This near conjunction (which is sometimes apparently an exact contact) of the gabbro with the gneiss, and the absence of the Animike proper between them, has been supposed to be due to a local overlap of the gabbro beyond the strike of the Animike, covering it from sight, the idea being that the gabbro flowed back northward over older formations, and came on to the gneiss.

2. Although there has not yet been any careful microscopic examination into the differences between the typical gabbro (for instance that seen at Rice's point, near Duluth) and the eruptive rocks that overlie the Animike black slates at Gunflint lake and eastward to Pigeon point, it has been noted that there are macroscopic distinctions which ought to be explained in case of a supposed parallelism of one rock with the other. The supposition has been that they are stratigraphically and chronologically the same, and that the differences were only local and unimportant. It was this assumed parallelism and the evidently later age of the eastern outcrops (the "crowning overflow" of the Animike) which has led to the placing of the gabbro later than the Animike. There is absolutely no other evidence. If these two eruptive rocks are not contemporary there is not only no reason against but considerable evidence in favor of placing the typical gabbro (such as at Rice's point, and at Little Saganaga lake) below the body of the black slates.

3. Boulders of characteristic gabbro and of red syenite, and of quartz porphyry, occur abundantly in the later "traps" of the Cupriferous. The quartz porphyry pebbles are so abundant as to constitute the well known thick beds of coarse conglomerate; and quartz-porphyry layers or lenticular *sheets* are interbedded between the trap sheets. This quartz-porphyry in some cases appears to have originated in its present condition of interleaved sheets during the time of the Cupriferous. This is observable at the mouth of Baptism river, and at the Great Palisades. At these points, however, owing to the proximity of bosses of gabbro rising above the rest of the country about, it is certain that those portions of the Cupriferous which contain the original quartz-porphyry beds, are near

the bottom of the formation. This is further shown by the existence, in the same region (at and near Beaver Bay), of large boulder-masses of gabbro in the trap flows, evidently derived from the neighboring gabbro hills. From this point, northward to the gneiss of the Giant's range, nothing is visible, in the form of rock *in situ*, except gabbro, or some "muscovado"-like rock described at some outcrops somewhat further west* by H. V. Winchell. The region is not fully explored, but it appears from all that is known, that there is nothing to be found of the typical, thin black slates of the Animike. It is as reasonable to infer that they followed after the gabbro flood, as that they preceded it. In case they followed after it, their typical characters were destroyed in this region by the frequent outbursts of igneous eruption, and they blended with the tuffs and shales and basic sheets that constitute, on the north shore of lake Superior, the lower portion of the Cupriferous formation. In case they preceded they must exist buried below the gabbro, as hitherto supposed.

4. In further consideration of the possible infra-position of the gabbro mass, below the Animike proper, attention should be given to the record of the deep well at Duluth, as given in Bulletin No. 5, of the survey. The interpretation of the record, given on page 34, shows, below the gabbro, (which is found to be 220 feet thick), quartzyte and conglomerate beds interstratified with imperfectly characterized gabbro, the whole having a thickness of 67 feet. Then followed trap sheets, and fragmental tuffs, for a thickness of 89 feet. Then follows what was thought to be the Animike, "evidently the Thompson slate formation." In the light of the foregoing (Nos. 1, 2 and 3) however, and on reviewing the descriptions given of the drillings of this well (pp. 31-34), the writer considers it quite doubtful whether "the Thompson slate formation" is on the horizon of the Animike of the northwestern part of the state. The existence of a minutely granular condition in the quartz (Nos. 39, 46, 50), recalling the "chalcedonic silica" of the Keewatin, and of a distinct slaty cleavage not due to sedimentary bedding (Nos. 23, 36, 37, 53), and of hydromicaceous or sericitic schist (Nos. 28, 30-39), and kaolinic itacolumyte (No. 41) noticed and recorded when the writer was impressed with the expectation of finding Animike characters, must be admitted to point to the Keewatin schists and graywackes. There are other coincident descriptions of the outcrops about Thompson, to be found in the tenth annual report (pp. 12-31) which throw doubt on the supposed parallelism

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*Seventeenth report, p. 90-91. Samples 387 (H).

of the Thompson slates with the Animike of northwestern Minnesota, viz:

1. Folia of quartz and slates, or schists interbedded, (p. 12, No. 454, p. 16, No. 466, p. 17, No. 472), is a character not known in the Animike.

2. There is a conspicuous perpendicular slaty cleavage in all parts which is not dependent on the sedimentary structure, a character not seen at all, or rarely, in the Animike in the northwestern part of the state.

3. The clay slates are frequently pyritiferous, (p. 18, No. 473.)

4. Feldspathic graywacke (often called gray quartzyte in the original descriptions) is a conspicuous feature in the strata north from N. P. Junction (p. 28, No. 504).

It is only intended here to make record of these reasons for hesitating before accepting the parallelism of the whole of the Thompson slates with the Animike of the northwestern part of the state, notwithstanding the fact that it has been accepted hitherto, both by the Wisconsin survey, the U. S. geological survey, and by the Minnesota survey.

5. On the supposition that the Animike black slates are involved in the Keweenawan, and, while overlying the gabbro, lose their typical characters at points further southwest, the interbedding of the Animike with beds of trap-rock, which is a common feature about Gunflint lake and on the shores of Loon lake, is easily explained, and indeed falls into place as one of the to-be-expected facts of such a period of recurring eruptions. It also obviates the necessity of a supposed change in the character of the eruptive rock, *i. e.* that the gabbro of Rice's point and Little Saganaga lake becomes, on Pigeon river, the dark or greenish trap-rock and the dioryte which inter-bed and characteristically overlie the Animike, forming the well-known "crowning overflow" of that region.

V.

FURTHER OBSERVATIONS ON THE TYPICAL HURONIAN, AND ON THE ROCKS ABOUT SUDBURY, ONTARIO.

In the summer of 1889, on the occasion of the Toronto meeting of the Geological Society of America, the opportunity was improved, both in going and in coming, to extend a former acquaintance made with the rocks of the region north and east of lake Huron.* A resume of these observations was read before the Minnesota Academy of Natural Sciences at the October meeting, 1889. In order that the bearing of the following facts and interpretations may be understood by any who have not given close attention to the developments of Archean geology in the northwest during the last few years, a brief resume may be the best introduction.

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* Compare the sixteenth annual report of the Minnesota survey.

It is well known that in the term Archean are included two groups of rocks, the Huronian and the Laurentian.* These terms are of long standing, and have been used in the geological literature of nearly all parts of the world, wherever geological research has been carried on in the oldest rocks. They were proposed by the Canadian geologists in 1855, and were in a few years adopted by the geologists of the United States, and they are yet found in nearly all of the text books of geology in use in this country, with the signification that the Canadian geologists have given them. It is not necessary to say here what inconsistencies were involved in this course of accepted nomenclature, nor what injustice was rendered to American geology by American geologists, nor what were the motives that apparently actuated the leaders of American geological opinion thirty or forty years ago. It is only necessary to say that *Huronian* was in conflict with *Taconic*, and that *Archean* was in conflict with *Azoic* as well as *Atlantic*, names that had been proposed earlier by United States geologists.

With the revival of work on the older rocks in the northwest, about ten years ago, it was found that the original Huronian of Logan and Murray had been amplified, by the reports of the later assistants on the Canadian survey, by an important extension of the names downward, over many varieties of rocks not mentioned in the Huronian region by those who first described the Huronian formation, and even over all the stratified, or schistose formations, down to the massive gneisses and syenites which are called distinctly *Laurentian*. This extension had also been accepted by many, if not by all, geologists of the United States. This was true of the late surveys of Michigan and Wisconsin, and of the earlier reports of the Minnesota survey, and was maintained, but haltingly toward the last, by Prof. R. D. Irving up to the time of his death.

In order to get a correct understanding of the character of the Huronian rocks of the original Huronian area, several recent reexaminations have been made of the area described and mapped by the Canadian geological survey. The first was that of Prof R. D. Irving, who came to the conclusion that the so-called Animike formation of Minnesota and Thunder bay (in Canada) is the equivalent of the original Huronian. But, unfortunately for the cause of correct nomenclature, Prof. Irving, who had embraced the expanded Huronian in his Wisconsin work, so continued his trip beyond the limits of the original Huronian, that he found, eastward from Algoma, a series of rocks which he thought also belonged in the same series with those at Thessalon, and so verified (?) his classification published in the Wisconsin report. Hence, while correctly assigning the real Huronian to its western equivalent (the Animike slates and quartzytes), he failed to see that outside of the mapped Huronian of Logan and Murray the name had no right to be extended over a different formation, for eastward from the mapped area another formation at once begins and hence, also, he continued to maintain that the Animike could be extended downward so as to cover all the lower schists and graywackes and iron ores of the Northwest.

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* C. H. Hitchcock has called attention to the fact that G. W. Featherstonhaugh proposed the term *Atlantic* for these rocks many years before Prof. Dana introduced the term *Archean*, and before Foster and Whitney employed the term Azoic. See *American Geologist*, vol. V, p. 199. Also compare *Geology of New Hampshire*, vol. 1, p. 325.

Prior to this an unconformity and a profound change in lithology had been discovered between the Animike formation and the schists below it, in the vicinity of Gunflint lake; and, at a later date, those schists had been examined in the region of the Lake of the Woods, and while placed doubtingly in the Huronian by G. M. Dawson, and by Bell, had by Mr. A. C. Lawson been given a new name, (Keewatin) who exempted them, questioningly, from the Huronian system, showing that they pass unconformably below the Animike which had been said by Prof. Irving to be the real equivalent of the Huronian on the north side of lake Superior.

In the sixteenth report of the Minnesota survey will be found two other recent descriptions of the original Huronian rocks, from an examination made in the summer of 1887. Here the Huronian formation is distinctly limited to the strata described at first and named Huronian by Logan and Murray, and the name given by Dr. Lawson for the underlying schists (Keewatin) is adopted unqualifiedly, and extended over those schists in Minnesota. The same classification had been adopted also in the fifteenth report of this survey, but without the authentication that comes from a fresh examination of the old data.*

As the current idea of the Huronian, as at length extended by the Canadian geologists, began to be questioned, several re-affirma-

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*The writer has reviewed the history of the Huronian system as expounded by the Canadian geologists, in the AMERICAN GEOLOGIST. *Methods of stratigraphy in studying the Huronian.* Vol iv. p. 342.

tions of its correctness have been published by Drs. Selwyn and Bell. It was in the light of these discordances that some recent re-examinations have been made, and the following notes were recorded when on a joint excursion with several geologists from the Toronto meetings of the American Association for the Advancement of Science, and of the Geological Society of America.

North Bay.—The rocks about North Bay,* on the northeasterly shore of lake Nipissing, placed in the Laurentian by the Canadian geologists, consist of dark-colored, micaceo-hornblendic gneiss, or gneissic schist. They are distinctly bedded by sedimentation, the characteristic belts of which run parallel for long distances. They are generally fine-grained and often red-weathering, recalling by this, as well by their structure and mineral composition, some gneisses seen and described by the writer in 1886,** on the Kawishiwi river. These are massive, fine-grained, red, very siliceous beds, as if from a quartzyte, but the most of the rock is closely laminated varying from very micaceous to very orthoclastic. The strata stand about vertical, but generally show some inclination southward—but sometimes northerly. The strike is about NW. and SE. Some of the gray gneiss (1573) which weathers reddish (1574) becomes contorted in some places and infolds, unconformably, masses of a dark rock very different from the gneiss (1575). These masses are wrapped round continuously with unbroken, but curved laminations of gneiss, the laminæ, at some distance from the enclosed masses, becoming straight again, and running in their usual course. These contrasted foreign enclosures have a different aspect, and a different composition from the micaceous belts of the gneiss. They are both micaceous and hornblendic, but mainly hornblendic; non-laminated and generally containing multitudes of fine crystals of cinnamon-garnet. In some places these masses are very large, and cannot be seen to be enclosed, but cut off the gneiss and replace it in large areas. The geology in general here recalls that of Northeast cape in Bassimenan lake (fifteenth report, p. 358), as well as that mentioned on the Kawishiwi river. The rock has been plastic *in situ* and molded about masses of foreign intruded rock, apparently a basic eruption, but has not been molten and extruded. In general the horizon to which it would be assigned in the Minnesota scale, would be near the bottom of the crystalline schists (the Vermilion series), or very near the Laurentian gneiss. It is very probable indeed that rocks like these have been included in the Laurentian in some of the descriptions and map-coloring in our reports. Since it graduates, in Minnesota, conformably on the one side into typical gneiss containing very much less mica, which would be placed unhesitatingly in the Laurentian, and, also, on the other hand, fades out by the loss of the black mica, and by the acquirement of a sub-crystalline and finally a fragmental texture, into the typical rock of the Keewatin, it is evidently only an arbitrary line of separation that can be drawn distinguishing it definitely from one or the other. The principal difference between it and the Keewatin consists in its more nearly perfect crystalline structure. The principal difference between it and the greater portion of the Laurentian gneiss in Minnesota consists in its greater percentage of black mica. The prevalence of the black intrusive masses oc-

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*The rocks about lake Nipissing have been described in the Canadian reports by Alexander Murray, for the year 1854, for the year 1855, and maps of the atlas accompanying the volume.

**See the fifteenth report, Minnesota survey, p. 353.

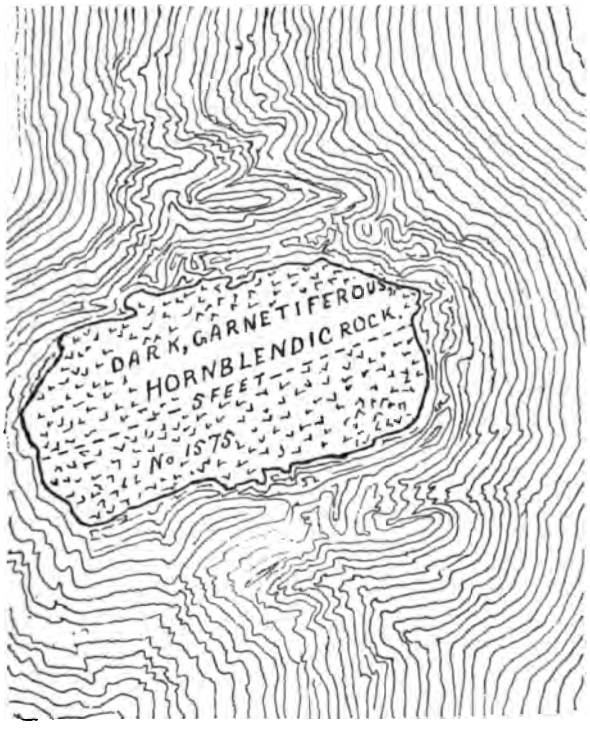

Fig. 11

Included hornblendic mass at North Bay, causing contortions in the gneiss.

Rock Samples obtained at North Bay are numbered as follows: 1573. Gray gneiss, the general rock at North Bay, after the weathered surface is removed. 1574, Reddish weathered gneiss, a surface condition. 1575. Hornblendo-micaceous and garnetiferous dark rock embraced in the gneiss (see figure 11) as foreign masses, and as large areas, the laminations of the gneiss being wrapped about them entirely and roughly conforming to their exteriors.

curring transverse to the strike of the gneiss, and in a manner involved with the gneiss, showing a mutually plastic condition of the two, is a characteristic of the Vermilion series about where the transition to the Laurentian occurs with an *eruptive unconformity,* the foreign intrusive rock being the dark, hornblendic masses and not the gneiss. The manner of occurrence of one of the smaller hornblendic and garnetiferous dark masses was sketched on the spot and the same is represented on page 51 (Fig 11). This was near the public school house at North Bay.

Wahnapitae. A sample of that which is here called Huronian by Dr. Selwyn is numbered 1576. At this point the formation changes from the Laurentian to the next higher, or supposed younger, formation. The train stopped but for a moment, but with difficulty a small sample of the country rock was procured. On examination it was found to be of a hydro-micaceous schist, silky-sericitic, evidently a part of the Keewatin. Subsequently Dr. A. C. Lawson re-examined this point, in order to get a better idea of the relations of the formations, and according to verbal description from him, there appears to be an unconformity of stratigraphy at Wahnapitae. similar to that at Penokee gap, Wisconsin; at the immediate contact the lower rock is the fine, micaceous gneiss, or mica schist, probably belonging to the series seen at North Bay, and the upper rock is quartzyte and gray argillyte interbedded.

At the Stobie copper and nickel mines, about three and a half miles north from Sudbury, there is a large exposure of greenstone. coarsely fibro-crystalline with hornblende (1579), seen south of the mines rising in high ridges and domes, resembling the ridges of the Kawishiwin greenstone of Minnesota (see the 17th annual report), though much more coarsely crystalline. This lies below the rock that contains the copper and nickel ores, and was fruitlessly penetrated by a costly shaft in pursuit of the ore-bearing rock several hundred feet. The present mining is done in a quartzyte (?) or at least a quartzose, apparently fragmental rock, which is superficially buried under a thick deposit of rusted debris, or gossan-cap, the result of its own decay. The ore permeates this gray granular rock in the form of sulphides which in this superficial layer is converted to oxides and carbonates. The mines are still not deep, although some tunneling has been done in the hillside. Outwardly the resemblance of the lithology of the lower rock (1579) to some of those described in northeast Minnesota belonging to the eruptive portions of the Keewatin is so great, that it is reasonable to suggest that it represents the lower formation. But the quarried rock cannot be assigned with any certainty to the same horizon. Its resemblance to some of the lower feldspathic, gray quartzytes seen in the Animike (Huronian), and its manner of occurrence in a low bluff apparently dipping at a low angle away from the lower greenstone, as well as the similar occurrence of abundant sulphides of iron (and nickel ?) in the lowest parts of the Animike west of Gunflint lake, caused me to regard the ore-bearing rock, on lithological evidence, as belonging to the true Huronian, and hence as unconformable on the other. Samples of the ore are 1578, and of the ore-bearing rock 1577.

At the Copper Cliff mine, three and a half miles s. sw. from Sudbury, according to Dr. Selwyn a dioritic dike (1581 and 1584) runs through the country, and the ore is associated with that. The next rock, on the north, is a red felsyte (1583), and the relations between it and the mined rock were not made out by anything I saw in the short time we were on the spot. The red felsyte becomes protogenic, or granitic, and also has fine black mica-scales developed in it in other places. The ore of this mine is represented by No. 1582. Eastward from the mine is a small knob of red felsyte, and next, about ¼ mile from the mine, is a knob of coarse conglomerate in which there are large boulders of red-weathering felsyte like that at the mine, also of laminated fragments of a grayish rock like a fine-grained graywacke or coarse argillyte, and probably others. The matrix is gray and finely siliceous, of which No. 1585 shows an average.

At 1½ miles from Sudbury, toward Onahping, the train stopped for the examination of a peculiar rock (1586), recalling, but not identical with, the hornblende-porphyry of Kekekabic lake (No. 751), but having much coarser crystals, and a more evidently conglomeritic original structure. At ½ mile further nw. this conglomerate is more crystalline, the matrix being reddish-weathering felsyte (1588), and the included masses being of a dark basic rock probably originally eruptive. In places this felsyte becomes granitic, and the large dark fragments appear as boulders and included masses more or less modified in shape, embraced as in a once plastic or molten rock. The aspect in such cases is much like some Laurentian, and if it were to be found to extend over a large area with these characters, it would probably be assigned to the Laurentian by any geologist. This illustrates one of the difficult problems involved in the use of the term Laurentian. This rock is in the midst of what passes for *Huronian*, and is derived from a fragmental rock which is like many seen in the "Huronian" of the region. It assumes first a porphyritic aspect, then it is felsitic, weathering reddish with a pronounced orthoclastic ingredient, then, with a coarser grain, it appears like an eruptive granite embracing masses of foreign basic rock. This is similar to some observations that have been made in Minnesota in the Keewatin, and particularly on the upper waters of the Kawishiwi river. Similar transitions have been observed in Michigan. *

At the Murray mine the ore (1589) is in a conglomerate, disintegrating and limonitic.

At Vermilion lake (*i. e.*, at the crossing of the Vermilion river), is a repetition of the falls, ridges and rapids seen at Thompson, Minnesota, the whole being manifestly of the same age, and supposed to belong to the Animike or true Huronian. The dip of these slates is 45° towards the S. Dr. Bell stated that the train, before arriving at Vermilion river, had passed over these slates for about five miles, viz; through a very flat and good agricultural tract, indicating a profound change in the underlying rock, inasmuch as, up to the place of entering on these slates, the country had been very rough, with frequent exposures of the rock. The slate is black, (or purplish black when dry), generally fine grained, yet with some evident grains of quartz, (No. 1590). In it are some curious calcareous bunches, or "concretions," which recall the soft masses in which Dr. T. Sterry Hunt reported evidences of a "keratose sponge," found near Thompson, Minnesota. Some of these masses are two feet in diameter, with rounded outlines, presenting on the weathered or glaciated natural surface a striking contrast with the rock which encloses them. They are locally designated "snow-shoe tracks." This brownish, calcareous material is represented by No. 1591.

From the Vermilion river, traveling still northwest, we passed on to a lower series of strata, the dip being to the south-southeast. This is a "slate conglomerate," (1592), and causes an immense ridge, 150 feet in hight, more or less. Into this rock Dr. Bell states that the slates at Vermilion river graduate conformably, and indeed so they seemed to do; and in this respect the succession seems to be like that seen in the region of the original Huronian northward from the Thessalon valley, as described in the sixteenth report of the Minnesota survey. This "black slate," therefore, and the underlying "slate conglomerate" should be considered as portions of the Huronian as described by Murray and Logan.

Immediately after passing this ridge of "slate conglomerate," the average surface level subsides again, and the country is more even. But the rock that succeeds to the slate conglomerate toward the northwest, is mainly a reddish felsyte, similar to that seen in the vicinity of Sudbury, and necessarily underlying the foregoing slate and "slate conglomerate." It is also broken up into irregular small knolls, and presents a confusion of dip and strike that contrasts strongly with the regularity of dip and strike maintained by the overlying formation. This formation seems to have supplied many of the felsitic and granitic boulders seen embraced in the slate conglomerate. There was no opportunity to make search for the immediate contact of the "slate conglomerate" on this rock, but if the observations that have been made recently in the area of the original Huronian, and on the Animike in Minnesota, be taken as guide, there would be found, on making such a search, a distinct overlap unconformity at such contact line.

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* Compare the 15th and 16th Annual reports, Minnesota survey.

From this point (Onahping) the excursion car turned back, and although it was planned to make a stop at Wahnepitae bridge to allow those interested to inspect the contact there between the Laurentian and the "overlying" formation, a heavy and continuous rain interfered, and the car returned directly from Sudbury the same evening to Toronto.

After this excursion I had the pleasure and the benefit of a further examination of the original Huronian region in company with Dr. A. R. C. Selwyn and Dr. A. C. Lawson. We walked from Algoma to Serpent river along the Canadian Pacific railway,noting the rock cuts, and the following is the general result of my own notes.

Quartzyte extends from Algoma to about one mile east, when a greenish slate (1593) appears with a dip s. 10° w, 45°—65°. This is fine grained and sometimes cut by dioritic dikes of epidotic rock, like that at Bruce. Next appears at 1½ miles from Algoma,a dark-gray roofing-slate (1594), the cleaving and bedding dipping southerly at an angle of about 75°. Below this is an immense stratum of "slate conglomerate"(1595), (3d of Logan's map of 1863), which is charged with boulders of various kinds of rock, the most conspicuous being of red granite. We then met with a soft fissile argillyte (1596) which hardly has any remaining sedimentary banding, and in it are elongated lenticular sheets of silica, apparently chalcedonic (1597). This resembles some seen in the Keewatin but there could be seen no contact, as the exposure is in the form of an isolated ridge which passes below the drift on all sides, so far as ascertained. It seems to be not a part of the argillyte before mentioned. This stands, in some places, nearly vertical. Then comes on a great quartzyte member (1598), but this is quite different from that seen at Algoma, and in the Thessalon valley. It is uniformly very fine-grained, and is apparently Logan's "gray quartzite," the lowest included by him in the Huronian. It is at any rate the same as the *Missasaugui quartzyte*, so-called in the 16th Minnesota report, which was there supposed to be Logan's lowest quartzyte. It is gray within and weathers red. The railroad swings back and forth across the ranges of this rock, following the easiest route, and affords some good opportunity to examine it. It exhibits important differences from the upper Thessalon quartzyte. It is interbedded with abrupt transitions from hard,apparently chalcedonic (?) silica, or quartzyte,to fine chloritic schists, the beds of the quartzyte being from a foot to two feet in thickness, and those of schist from two to eight inches. This extends for at least four miles, with some interruptions, the road passing in general at an oblique angle across the strike of the formation. The beds are for long distances straight and parallel. At a distance the face of the rock recalls the regular and straight furrows of a plowed field,the schist weathering and washing out easier than the quartzyte. Such a view is seen on the south side of the track about four miles from Algoma.

At a point still further east the conglomerate recurs by the track. Here it holds quartzyte pieces like the quartzyte just mentioned, and also others of red granite, and numerous pebbles of bluish vitreous quartz. It also embraces pieces of nearly black argillyte (1599) which is soft and has a nearly white streak.

After an interval of nearly a mile and a half of no rock exposure, we encountered a low boss of fine-grained black mica-schist (1600); with siliceous veins running with the strike. Then we found some argillitic beds in which were some crumpled white sheets of apparently chalcedonic silica (1601).

After an outcrop of coarse quartzyte (1602) resembling somewhat the Thessalon quartzytes, but less granular, whose stratigraphic position we could not make out, on account of the interrupted nature of the exposures and the variation in the direction of the track, we noticed two dikes of more recent diabase (1603) cutting the slate conglomerate and running nearly coincident with the strike, and having a columnar structure about horizontal. Under the conglomerate here, *i. e.* just before reaching Cook's Mills, at the mouth of Serpent river, conspicuous outcrops appear of a fine mica schist (1604), which is probably the recurrence in force of the mica-schist before mentioned (1600). It is not bedded but massive, and becomes hornblendic, recalling some parts of the Vermilion series of Minnesota. This continues to Cook's Mills and forms the outcropping rock at the station and about the village. No positive observation was made on the stratigraphic relation of this hornblendic mica-schist to the slate conglomerate, but its place is assumed to be below the conglomerate because of the known relation of the Huronian (*i. e.* the described Huronian of Murray and Logan) to such rocks in other places.

SUMMARY OF THESE OBSERVATIONS.

It appears, therefore, that both northwest from Sudbury and eastward from Algoma there are two formations. The slate and the slate conglomerate in both sections constitute the upper formation. In the region northwest from Sudbury the underlying rocks are largely felsitic, but are also micaceous, and at the Stobie mines become hornblendic. These changes are identical with changes that are known to occur in the Keewatin in Minnesota. In the section eastward from Algoma the underlying formation seems to be the Missasaugui quartzyte with interbedding of green fissile schist, in part, and a mica schist varying to hornblendic schist, in part, the latter being further east.

There seems to be some irregularity in the order of succession in the section eastward from Algoma, bringing in several outcrops of strata that belong higher up in the series. If this be not illusory, and due rather to the winding of the railroad from north to south to avoid the hills, it may be accounted for by such faulting and upheaval as have been described in Minnesota, such as have produced the sudden, but indistinct, unconformities and transitions from the Huronian to the Keewatin, that have been described there. Further, the quartzyte which has been alluded to as the Missasaugui quartzyte, and supposed to be Logan's lowest gray quartzyte, is probably not his lowest gray quartzyte, but it is rather a constituent part of the Keewatin. It is allied in all its lithology no less than its persistent verticality to the Keewatin and seems to have been formed in the Keewatin ocean in the same manner as the jaspilyte beds of that horizon, *i. e.*, by chemical precipitation, the green schist layers showing such advent of basic eruptions or volcanic ash as could form chloritic schists in the same way as in northeastern Minnesota. The "lower gray quartzite,'' (No. 5 a), of the original Huronian, according to Logan's map of 1863, appears a few miles east of Thessalon at the lake shore, and there produces an unconformable contact on the gneiss of the Laurentian. This contact has been examined by Prof. Irving and more lately by Dr. A. C Lawson, and they concur in the statement that the conglomerate is a pudding-stone of rounded masses, having a quartzyte matrix. There can be but little doubt that it is the same as that seen in the vicinity of Thessalon, and hence that it is the Thessalon quartzyte and overlies the slates and slate conglomerates, being near the top rather than near the bottom of the original Huronian. This mistake is apparently the same as made in eastern New York and in Vermont, where the granular quartzyte and the Potsdam or red sandrock seems to overlap and hide from sight the formation immediately older, and lies in unconformity on a still older terrane—on the east on the gneiss of the Green mountains, and on the west on the gneiss of the Adirondacks. It caused the early geologists to question the existence of any such formation as the Taconic—that great series in which has been brought to light latterly a wonderful fauna of primordial life, and which extends from the Atlantic slopes to the western basis of the Rocky mountains. This overlap unconformity implies a sinking of the pre-existing land, and of the ocean's bed, bringing the later formed strata over the beach-limit that existed before.

We may conclude therefore that the observations that were made on the recent excursions confirm, at least do not contravene, the views lately set forth by Irving, Bonney and Lawson, and the conclusions published by the reports of the Minnesota survey, to the effect that the Huronian system, as now defined and understood by the Canadian geological reports, really embraces two or three formations: that one of these is the true Huronian, as at first described and mapped by Murray, another is the Keewatin of Dr. A C. Lawson, containing the iron ores at Tower, Minnesota, and another is the series of crystalline schists which we have styled Vermilion series. In other places these three formations have been fully treated.* They are distinctly separated by lithology and unconformities that have been noted from Vermont to Minnesota, and

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Note.—At A[illegible] very interesting boulders [illegible]. They contain large [illegible] spots which are distributed somewhat [illegible] periphery of crystals. They [illegible] and the spots make the rock [illegible] larger than an inch in diameter. Some [illegible] noted which the Canadian [illegible] is where we saw them first. Mr. Sel[illegible] ridge back of Silver Islet as the [illegible] place. This dike was visited in 187[illegible] by the [illegible] Tenth annual report, p. [illegible], but the crystals [illegible] greenish. These boulders are [illegible] country toward the north [illegible]

Another [illegible] of quartz-pebble conglomerate [illegible] seen in the Missassagua quartzyte [illegible]. While the boulders themselves [illegible] Huronian, the pebbles that [illegible] unconformably underlying ver[illegible] quartzyte [illegible] Missassagua quartzyte seen, as above described, a few miles east of Al[illegible].

* See the Seventeenth Annual Report, Minnesota survey.

should no longer be included under a single term—at least not under the term Huronian, which at first had a correct and adequate definition embracing but one of them.

VI.

Additional Rock Samples Numbered.

[Collected by N. H. Winchell, intended to illustrate his field notes in 1888 and 1889.

1501. Vein rock and pyrites, from the quartz vein supposed to be auriferous, at Eagle Nest lake, east of Vermilion lake; according to Robert Augst this also contains metallic copper. [See description of this vein in the 15th annual report, p. 32.]

1502. Chemical silica, Tower, embraced in considerable masses in immediate proximity to the chalcedonic, in the green schist.

1503. Chemical (granular?) silica, in a vein about half an inch wide running transverse to the green schist, Tower.

1504. Chalcedonic silica, immediately adjacent to 1503; reddish, in thin laminations.

1505. Some of the schist seen interstratified in argillitic slate at the low "slate" knoll south of the "south ridge" and west of Tower.

1506. Four samples showing the relations of the chemical silica to the hematite, at the Lee mine, near Tower.

1507. Brecciated jaspilyte, cemented by a finer breccia of the same. From a boulder, but fairly illustrating the beds in situ.

1508. Black schist with pyrite balls, at the pits at the N.W. base of Chester peak.

1509. On the top of Chester peak some small veins consist of chalcedonic silica, crossing the jaspilyte banding.

1510. At Ely; a sample of the green schist showing the forms of two boulders, and the darker green rock separating them.

1511. Amygdaloidal portions of some of the boulders, showing the tubes perpendicular to the surface; from the green agglomerate at Ely, at the railroad cut.

1512. Chalcedonic silica from veins and spots in the rock 1510.

1513. Vein matter in 1510, similar to 1501. Probably auriferous.

1514. Sample of the gneiss at the Hinsdale quarry, *i. e.*, in the Giant's range.

1515. Frazer's quarry, North Redwood P. O., near Redwood Falls, on the Minnesota river. Massive, gray, uniform gneiss, without bands of color.

1516. Same place. Gray gneiss, with alternating and intershading micaceous and feldspathic belts.

1517. Same place; samples showing much red orthoclase.

1518. Gneiss, with much red orthoclase. Morton quarries, near Redwood Falls.

1519. Gneiss, showing inclusion of a micaceous, "black rock." Morton quarries.

1520. From a granite mound on sec. 12, T. 111—38. Redwood county. A bedded granitic rock, showing no red orthoclase.

1521. The gray quartzyte at Pokegama falls on the Mississippi river near Grand Rapids. Compare 257 (H)—259 (H).

1522. The gneiss at the upper falls of Prairie river.

1523. Showing micaceous schist in alternations with the gneiss at the upper falls of Prairie river.

1524. Coarsely crystalline orthoclastic belts, from the gneiss at the upper falls of Prairie river.

1525. Reddish and chloritic mass wedged in the gneiss at the upper falls of Prairie river.

1525 (a). Spottedness shown on the quartzyte at Prairie river.

1526. Shows another spottedness. Here the rusty spots weather out and produce a pitted surface on the quartzyte; same place.

1527. Hematite and impure hematite, siliceous and jaspery. Prairie river falls.

1528. Rock shown at about the horizon of this hematite.

1529. Somewhat above 1528. Finely laminated or "streamed," also brecciated, jaspilyte, with some vitreous silica.

1530. Jaspilyte and hematite, closely intermixed, but not interlaminated. The red jaspilyte appears as a felsyte.

1531. Hematite at this horizon; about one-fourth is hematite.

1532. Some of the quartzite that underlies this ore is conglomeritic in patches.

1533. Red shale. Griffin's camp, N. E. ¼ Sec. 22, 56-24.

1534. Iron-bearing rock. The ore impure and in broken and irregular sheets; hematite.

1535. Same as 1534. Pit No. 2, but struck at 15 feet below the surface.

1536. Same as 1534. Pit No. 3. Struck at one foot below the surface.

1537. Slaty hematite, rather low grade (47 p. c. iron) N. W. ¼ N.W. ¼ Sec. 21, 56-14.

1538. Magnetic iron ore, Sec. 23, 60-23. Fleck's location; from John Beckfelt.

1539. Rock associated with 1538.

1540. Duluth; on the Weller road, about 1½ miles from lake Superior, but about 2 miles from the business part of Duluth. Gray, porphyritic gabbro, with a fine magma.

1541. Shows contact of the "red rock" on the gray rock 1540.

1542. Red rock, crystalline. with some light-green spots, from the Weller road, same place as 1540.

1543. Granular silica, appearing somewhat as if originally chalcedonic (see 519). Same place.

1544. Vein matter in gabbro, at Rice's point.

1545. Serpentinous vein matter in gabbro at Rice's point.

1546. Quartz crystals lining vugs in dense hematite. Lee mine, near Tower.

1547. Reddish, earthy-looking jaspilyte. Lee mine.

1548. Breccia of fine pieces of hematite, red jasper and quartz, somewhat stratiform. Lee mine.

1549. Tarnished hematite, appearing as if it might be some copper sulphide; Lee mine. Coatings; Lee mine.

1550. Finely banded (sedimentary?), whitish jaspilyte; Lee mine.

1551. Hard hematite, with included crystals of chalcopyrite.

1552. Piece of chalcedonic quartz mass, embraced in a boulder of Stuntz island conglomerate (agglomerate), near the Lee mine.

1553. Piece of gray quartzose pebble or gray "felsyte," contained in the same boulder as 1552.

1554. Pebble from the same boulder containing vitreous quartz.

1555. Matrix of this boulder containing the above pebbles.

1556. No. 1553 becomes porphyritic in 1556.

1557. Light colored graywacke, or novaculyte, greenish white, with distinct grains of glassy quartz: at the railroad just south of Tower pit (Nos. 8 and 9). Dips N. about 75°—80°.

1558. Green schist, south of the Stone mine, at the railroad cut.

1559. Interbedded jaspilyte in 1558.

1560. Fine grains of disintegrated white jaspilyte; dump of the Stone mine.

1561. Breccia of jaspilyte and of hematite cemented by chemical silica; dump of the Stone mine.

1562. In the dump of the Stone mine some of the quartz crystals are superficially roughened and corroded—some of the fine crystals. What caused it?

1563. Green shale breccia; from the dump at the scram southwest of the Breitung mine.

1564. Botryoidal limonite on quartz crystals and on hematite; same place.

1565. Flinty, gray to dark gray jaspilyte, from the dump of the hoisting-shaft of the same place. Compare 866 B. and 1277.

1566. Rotted, angular masses of jaspilyte as intersected by the water-bearing course of a joint crossing a mass of contorted jaspilyte, at the Breitung mine.

1567. Pebbly conglomerate, embracing small grains of vitreous quartz; a patch or belt in otherwise typical jaspilyte. In the ridge that remains separating the Breitung from the Tower mine.

1568. A jaspilyte egg, somewhat concretionary, at least indistinctly concentric in some color bands. From the cut made for the high tunnel running south from the To it (No. 9), where it crosses the light "ore streak."

1569. Coarse graywacke, rather soft, taken from the roof of the same tunnel, crossed by some thin veins of chalcedonic silica, about 15 feet from the southern entrance.

1570. From the dump, Breitung mine. What is the fine red mineral in crystals?

1571. Siliceous "green schist" interbedded in jaspilyte north of the Tower mine.

1572. From the jasper at the east end of the Stuntz mine. What is the white cementing vein-mineral? It appears to be granular silica, but also shows apparently cleavage surfaces.

1573. Gray gneiss, the rock at North Bay, on lake Nipissing, Ontario, in general, after the weathered surface is removed.

1574. Reddish-weathered gneiss, a surface condition of the rock at North Bay, Canada.

1575. Micaceo-hornblendic, garnetiferous rock embraced in No. 1573, as foreign masses, some of them fifteen feet across.

1576. Hydro-micaceous schist, silky-sericitic, from the "Huronian" at Wahnapitae, Ontario.

1577. The rock that contains the nickel ore at the Stobie mines, near Sudbury, Ontario, a gray quartzyte resembling the Pewabic quartzyte of Minnesota. Compare 1322 and 1340.

1578. The ore from the Stobie mines, Ontario.

1579. The "hornblendic rock" from the dump of the deep shaft which was abandoned at the Stobie mine, Ontario.

1580. Orthoclase found in veins in 1579.

1581. The dioryte dike which is supposed to cut the country rock at the Copper Cliff mine, Ontario. With this the ore is in some way associated.

1582. Ore of the Copper Cliff mine.

1583. Red felsyte, adjoining 1581 on the north.

1584. The conditions of the mined rock and the sulphides at Copper Cliff mine, Ontario.

1585. Matrix of a coarse conglomerate with boulders of red-weathering felsyte, one-quarter of a mile east of the Copper Cliff mine, north of the railroad.

1586. Porphyritic rock, the disseminated crystals being of hornblende and coarse. At the railroad cut, a mile and a half from Sudbury, toward Ohnaping.

1587. Dike-rock, cut by the grade, near the same place.

1588. Somewhat granitic felsyte, enclosing masses of dark basic rock in a manner like those at North Bay; reddish weathering; a quarter of a mile further toward Ohnaping.

1589. Ore of the Murray mine, Ontario.

1590. Black slate, Vermilion river, at the railroad crossing.

1591. Calcareous "concretions" in the black slate at Vermilion river. Same place.

1592. Slate conglomerate, N.W. from Vermilion river; from a ridge that rises perhaps 150 feet above the railroad.

1593. A mile and a quarter east of Algoma, on the north shore of lake Huron. Green slate, dipping S. 10°, W. 45°-65°.

1594. A mile and a half east of Algoma. Roofing slate, gray to black.

1595. Slate conglomerate, 3d of Logan's map. Underlying 1594.

1596. Soft argillyte, with lenticular spots and laminations of chalcedonic silica, next east of the slate conglomerate of 1595.

1597. Supposed chalcedonic silica, from 1596.

1598. Fine grained quartzyte, about 4 miles east of Algoma.

1599. From the great "slate conglomerate" east of Algoma, at a point east of the last.

1600. Fine-grained, nearly black, mica schist; at a mile and a half east of the last.

1601. Crumpled, white, apparently chalcedonic silica, from some argillitic beds east of 1600.

1602. Coarser quartzyte, still farther east.

1603. Dike-rock, cutting conglomerate.

1604. Hornblendic schist, Cooks Mill, at mouth of Serpent river.

1605. Diabasic boulders, with coarse feldspar crystals. Found at Algoma (compare 601).

1606. Quartz-pebble conglomerate boulders. Algoma Mills.

VII.

AMERICAN OPINION ON THE OLDER ROCKS.

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With incidental citations from Chester Dewey, W. W. Mather, L. Vanuxem, James H. Safford, William B. Rogers, Alexander Murray, J. J. Bigsby, J. Barrande, A. R. Selwyn, J. B. Marcou, Robert Bell, L. W. Bailey, Thomas Macfarlane, J. W. Dawson, C. T. Jackson, J. W. Foster, M. E. Wadsworth, C. R. VanHise, T. C. Chamberlin, James D. Dana, Charles D. Walcott, and others.

By ALEXANDER WINCHELL, LL.D., F.G.S.A.

INTRODUCTION.

As preliminary to a careful inquiry into the nature, arrangement and geological history of the older rocks of North America, I desire to collate the views which have been recorded by competent geologists during the last half century. Such a synopsis of opinions which have marked the progress of our science and have brought it through many labors, conjectures, errors and successes, to the very creditable position which American geological science holds at the present day, will greatly facilitate the work which remains to be done, by placing within convenient reach, the chief data of such progress, with copious references to the documents from which the information is drawn. Such a compendium of historic data will prove especially useful to geologists who have not the leisure to look up and digest the original documents. Since however, compilations of opinion, though offering opportunities for condensation, and even improved lucidity of statement, must necessarily lie under the suspicion that the author's view has been presented with incompleteness or with unintended coloring, the writer has deemed it best to present opinions generally in the exact language of their authors.

The present attempt bears some resemblance to that of Messrs. Whitney and Wadsworth in "Azoic system"[*]; but it will readily be seen to have a different aim, and to produce results far from identical. Their controlling purpose was, to prove, from citations, that during the time which has elapsed since the "Azoic System" was proposed by Foster and Whitney, no facts have been reported rendering it necessary to conclude that the "Azoic System" as conceived by them, is not both azoic and indivisible. My purpose involves an examination of such a position, but it involves much more. I propose to adduce the facts without the influence of an unalterable predetermination. I propose to select them impartially—rather in the interest of the writers than in the interest of any theory. I propose to give them an unbiased interpretation or to leave them without comment, to be interpreted by the reader. Beyond all this, it is proposed to cite many opinions not bearing on questions of taxonomy and nomenclature—opinions on all subjects whose agitation has taken part in the progress whose fruits we enjoy—problems of structure, superposition, metamorphism and geognostic evolution in general.

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[*] J. D. Whitney and M. E. Wadsworth, *The Azoic System and its proposed subdivisions*. Bulletin of the Museum of Comparative Zoology. Geological Series. Vol. I. pp. xvi and 331-565.

The method of Whitney and Wadsworth is geographical; mine may be denominated personal; neither traces consecutively the evolution of an idea or concept. Concrete methods have peculiar uses; and it is hoped the method here pursued may be useful as complementary to theirs, even if its subject matter possesses fewer advantages than I anticipate.

In some of these respects the method of the following sketch resembles that of Dr. Hunt in his Historical Introduction to the Azoic Rocks[*]. It differs, however, in the important feature of giving the views of investigators in their own language. One does not feel certain, in reading the memoir of Dr. Hunt, that he gets exactly the meaning of the original statement. In some cases, it is certain, the meaning is inadvertently colored, or even reversed. Dr. Hunt's treatment also, seems to the writer, deficient in method. It lacks consecutiveness; it abounds in repetitions; the connection of parts is more verbal than logical. The order would seem rather to be that of association of ideas in the author's mind than one determined by the logical or historical relation of topics. For such reasons, it is difficult to follow and comprehend. However this may appear to others, it seems certain that comprehension and clearness of conception must be facilitated by following the growth of conviction in each investigator's mind separately—introducing the biographical element into the history of geological ideas.

In the history of this advance, it has been the fortune of some to observe nature in the field, of others, in the laboratory, of still others, to collate records in the library—and I need hardly remind the reader that the efforts of many others have been expended in provinces not entered in the present discussion. Those who have worked in the field have supplied the greatest volume of records suitable for use in the compilation which follows.

In attaining the status which has been achieved, there must have been many false steps taken—erroneous observations, false interpretations, hasty generalizations, untenable suggestions, ill grounded theories, all mingled from time to time, with the influence of the "personal equation." Still, it is safe to assume that every investigator has been actuated by a controlling love of truth, and has done perhaps, as well as any other investigator would have done in precisely the same circumstances. If any have lost patience with a fellow-worker, it is profitless to reproduce the sarcasm in which impatience has found relief. The language of scorn or contempt has contributed nothing to the noble progress which we contemplate.

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[*] Report E, Second Geological of Survey Pennsylvania.

As intimated, the present summary of opinion sustains a special relation to the contemplated sequel of the present memoir. Whatever its separate value may be, its use to the writer consists in the light which it sheds on an investigation to a large extent original. Circumstances have turned the writer's attention, during a few years past, toward the study of the older rocks. Though from boyhood familiar with the forms and aspects of the crystalline and sub-crystalline masses of Dutchess, Litchfield and Berkshire counties; though officially connected with public surveys over the crystalline expanses of Michigan; though long since a student of similar rocks in Missouri, Massachusetts and Maryland, it is true that the present research has been in a field comparatively new, and conducted by methods in part unknown to the older investigators, and but imperfectly mastered by most of us. It has seemed to the writer that one of the fields in which he has studied presents the problem of the older rocks under simplifications which promise advantages not enjoyed by the older students of terranes of high relative antiquity. Perhaps he deceives himself in thinking these advantages have brought him—a comparative novice—into possession of glimpses of truth which have been hidden from abler, but less fortunate students. He hopes however, the result will justify his confidence.

EBENEZER EMMONS.

1824. Ebenezer Emmons, in 1824 a pupil of Dr. C. Dewey, was associated with the latter in the preparation of a geological description and map of Berkshire county, Massachusetts, and of a small part of the adjoining states.[*] In this description the rocks are arranged in the following order (the whole being here inverted):

3. Transition limestone, &c.
2. Quartz, Primitive limestone, Primitive argillite (Upper Primary).
1. Granite, Gneiss, Talcose slate, Mica slate (Primary).

The second division indicates the elimination of the "Taconic' idea" eighteen years before it received a formal designation.[**]

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[*] *American Journal of Science and Arts*, Vol. 8, 1824. pp. 1, 240. An abridgement of this was included in "A History of Berkshire County," in 1829.

[**] 1819. In a "*Sketch of the Mineralogy and Geology of the vicinity of Williams College*" (*Amer. Jour. Sci.*, Vol. I, p. 327, II, 246, 1820.) Dr. Dewey had already published the germinal conception of the above arrangement, and of the Taconic system. The rocks and minerals were arranged in the following order: 1. Granite. 2. Gneiss and Mica

1837. At the end of the first season's observations within the Second Geological District of New York, professor Emmons described the rocks, in the nomenclature of the day, as Primitive, Transition and Tertiary.[*] Under the first, he describes first, Granite, which is "not strictly speaking, granite; that is, it is not composed of quartz, feldspar and mica; neither is it a true sienite, for even the hornblende disappears almost entirely for miles. It is mostly feldspar. . . . It contains the beautiful Labrador feldspar . . . often in large masses. . . . The color of the rock is usually grey, greenish or bluish. . . . It rarely contains quartz. . . . In Essex county it forms mountain masses. . . . The other primitive rocks of the northern counties are gneiss, hornblende and granular limestone. The talcose and mica slates rarely occur." The following is the succession reported, arranged here in descending order:

TERTIARY, consisting of grey sand and marly clay, with shells of recent aspect.

TRANSITION ROCKS. 1. Calciferous sandrock, including Potsdam sandstone. 2. Transition or blue limestone.

PRIMITIVE. Granite, Gneiss, &c.

1838. Professor Emmons again ranges the rocks of St. Lawrence county as Primitive, Transition and Tertiary[†]. The Primitive region he also designates "the gneiss district," but he states that "the rock is not purely gneiss," but only "the predominant rock," the region embracing also "granite, limestone, sienite, hornblende, steatite, serpentine, &c." The granite, he says, "occurs in beds and veins subordinate to the gneiss; . . . in huge angular beds or protruded masses; in the form of veins branching irregularly into the adjacent rock, and in overlying masses analogous to overflowing lava currents or greenstone." He speaks of it as sometimes "interlaminated with gneiss or other rock," but considers such position "accidental" (p. 196). The granite and gneiss contain in places, more or less carbonate of lime, or of lime and magnesia. The "primitive limestones" he speaks of as interstratified, but is particular to discriminate them from the marbles of Vermont and Massachusetts, "especially those of Berkshire county."[‡] He gives eleven diagrams to illustrate the position that

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slate. 3. Quartz. 4. Granular limestone. 5. Argillaceous slate. It will be noted that there is one limestone formation. These views were adopted by Prof. Amos Eaton in his "Index to the Geology of the United States," 1820, though later, he became an indefatigable original observer. (*Amer. Jour. Sci.*, xiv, 147, 1828.)

[*] *First Annual Report*, New York, 1837, Assembly, No. 16, pp. 109-117.

[†] *Second Annual Report*, New York, 1838, Assembly No. 200, pp. 194-217.

[‡] This is further insisted on, p. 232.

we have the same evidence of the igneous origin of the primitive limestone as of the igneous origin of granite—that is, it occurs interbedded, penetrating and ramifying in relation to the granite.[*]

The sandstone at Potsdam is said to rest directly on the primitive rock, but it is no longer identified with the "Calciferous sand rock" of Eaton, (p. 214). On page 217, it is called for the first time, "the Potsdam sandstone" (pp. 217, 230.)

Treating of Essex county he speaks of the granite as "composed essentially of Labrador feldspar and hypersthene," and decides to style it "Hypersthene rock" (p. 220). It contains extensive beds of iron ore, sometimes branching and vein-like. The primary limestone "uniformly occurs in veins" in the hypersthene rock. The gneiss of the country is limited in extent, is interlaminated with saccharoidal limestone, and contains beds of magnetite and hæmatite (p. 221).[†]

We have no documentary evidence of the progress of the evolution in Dr. Emmons' mind previously to the publication of the Gazetteer next to be mentioned. But professor Dana has recorded the fact[‡] that, according to information from professor James Hall, a discussion of "Taconic ideas" took place at the meeting of the "Association of American Geologists and Naturalists" at Philadelphia, in April, 1841. In this, Dr. Emmons was opposed by H. D. Rogers, E. Hitchcock, W. W. Mather and James Hall, while Lardner Vanuxem favored his views.[‖]

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[*] Numerous other reputable geologists have entertained the same rather remarkable opinion—von Leonhard, Gludini and Rozet.

[†] The Tertiary beds are of some considerable extent, occupying "not only the Champlain valley but that of the St. Lawrence and Hudson also." He notes it as a "marine formation," and states that "above these clays, &c, we have the modern group composed of boulders, pebbles and sands" (238). Emmons here bestows the names "Mt. Marcy" and "Adirondack group" or "Adirondacks"—the latter to embrace the high summits of northern New York. (pp. 242, 243).

[‡] *Amer. Jour. Sci.* III., xxxvi, 412.

[‖] The Proceedings of this Meeting are found in the "*Trans. Assoc. Amer. Geologists and Naturalists*, 1840-42. but this discussion not having been reported, no mention of it appears, under a rule of the Association. The proceedings are reported also, in *Amer. Jour. Sci.*, xli, 158, 1841. The grounds of Vanuxem's defence are stated in *Report on the Third District*, 1842, pp. 22-23. He styles it "The Taconic or Intermediate System," and says, "the Cambrian System holds the same position." Mather's reasons for regarding the Taconic rocks as a metamorphic condition of the Champlain rocks are given (p. 438) at the close of a chapter on the Taconic system; also p. 464 (*Report Third District of New York*, 1843, pp. 422-438). Professor Hall in his report on the Fourth District, embraces the Taconic system in his enumeration, and nowhere expresses any dissent.

"The comparison of views at the meeting", says professor J. D. Dana, (*Amer. Jour. Sci.*, III., XXXVI, 413, Dec., 1888) "resulted in inducing Prof. Rogers and Prof. Hall to take the field for the study of sections over the Taconic region. The season had just passed when Prof. Rogers made a report on his results to the American Philosophical Society at Philadelphia (*Proc. Amer. Phil. Soc.*, Jan., 1842) sustaining the views which Hitchcock, Hall, Mather and himself had before favored".

1841. A communication appeared from Dr. Emmons on "The Geology of Montmorenci,"[*] which, according to Dr. Selwyn, "seems to be of considerable interest and importance, in view of recent discussions." It supplies some of the evidence on which Dr. Emmons determined the existence of a great fault, reaching from the St. Lawrence into Vermont and New York. On the highway from Quebec to the falls, at the Beauport river, a regularly bedded, horizontal, nearly black limestone outcrops, "presenting a remarkable contrast with the highly inclined rocks of Quebec." A "black slate," also, "apparently rests against" the limestone. A fault or uplift is thought indicated by the facts here observed," along the line which the road passes." The first outcrop is" very clearly Trenton limestone," and "the slate is the Hudson River slate."

At the fall, the bed of the river above, is gneiss. Reposing horizontally on its edges, is, first, the Potsdam sandstone, stained with copper, and not over ten feet thick; second, coarse bowlders, as at Chazy, N. Y., considered the upper portion of the Potsdam; third, "a compact limestone" conformably overlying, containing encrinites. This "graduates into a gray, crystalline limestone," with broken encrinites. Succeeding this is the Trenton, 60 or 70 feet thick. The absence of the Calciferous and Chazy is noted; though this is not considered remarkable.

Below the fall, the rock forming the fall is seen to be fine-grained gneiss. Against this, the Black slate of the Hudson river reposes, but with an unconformable inclination. Dr. Emmons recognizes here a fault, with an uplift on one side "and a down heave on the other, by which the slate has been thrown into an inclined position."

This fault is regarded as extending south along the Beauport road, and even into the state of Vermont; and "may be particularly traced on a line connecting Johnson's mountain in Lower Canada, several points on the Missisque bay adjacent to the Provincial line, and also, at the remarkable uplift at Snake mountain, in Addison, Vt. A line uniting those points and several others in the same direction, marks the line of a great disturbance which has deranged the lower Transition rocks for at least four hundred miles."

In view of these facts, Dr. Emmons asks; "May not the great fault have caused the confusion in the writers on geology, in regard to the lower Transition rock, particularly the Hudson River slates and shales? May not the same derangement exist in England and Wales, and have been the cause, at least in part, of their separation from the Silurian system, and of their being considered as one distinct therefrom, and which has been called the Cambrian System?"

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[*] The *American Magazine*, November, 1841. See this reproduced in *American Geologist*, ii, pp. 94-100, August, 1888. The date of this paper was wrongly printed in the *American Geologist* at first, but was corrected afterward (vol. iv, p. 387).

He speaks of the horizontal position of the Hudson River rocks at Pulaski, Lorraine, Rodman and Pinckney, in New York, conformable with the Silurian system; and of their inclined position in Rensseler and Washington counties, in Vermont, and the entire length of Lower Canada. In the latter region, they agree with the Cambrian (omitting the lower portion.) He speaks of this as a conviction of long standing.

He continues: "It is proper to notice here one source of difficulty in regard to the rocks of the Hudson river, especially on their eastern border. It is the fact of their overlapping in this direction, the Trenton limestone and the other Transition rocks beneath. The consequence has been that, in traveling from east to west, or from Massachusetts and Vermont to New York, we pass directly from the Primary mass to the higher members of the Transition system; consequently they [geologists] have placed them upon the Primary, and considered them as the lowest of the Transition; whereas there intervenes between the Hudson river slates and the Primary, the Trenton limestone, the Birdseye, Calciferous, and Potsdam sandstone, the aggregate thickness of which exceeds a thousand feet. Not one of the lowest members of the Transition system appears in the eastern prolongation, between the Highlands of the Hudson and the Highlands north of Quebec, adjacent to the Primary, in consequence, as has already been said, of the overlapping of those rocks formerly termed Greywacke, or now known as the Hudson river series, to the talcose slates of the Primary, and also, the great correspondence in kind and amount of their dip."

Speaking of the tenuity of the Hudson River rocks where found horizontal, and their great thickness where inclined—amounting to 20 or 25 miles—he says:—"There can be no doubt that east of the Hudson, there are numerous repetitions of the same layers; for it cannot be supposed for one moment, that any of the formations above the Primary, can be of this enormous thickness which observation seems to indicate."

1842. While occupied in the preparation of his final report on the Second District of New York, Dr. Emmons drew up an article on the "Topography, Geology and Mineral Resources of the State of New York", which was published in March, 1842.[*] In this article he says: "The rocks (upon the eastern border of New York, adjacent to Vermont, Massachusetts and Connecticut) are situated between the gneiss of Hoosick mountain on the east and the slates of the Transition on the west. They occupy, therefore, geographically, as well as geologically, an intermediate position–the rocks on the one hand bearing a very close resemblance to the Primary on the east, and on the other, a great similarity to the Transition slates on the west. Still, as a whole, the rocks of the Taghkanic range may generally be distinguished from those on either side, their general character being derived from the presence of a large proportion of magnesia, which imparts to the rocks a softer feel and a peculiar greenish color. It is not proposed in this plan, to separate these rocks from the Primary, but to consider them as belonging to the upper portion, and to speak of them as the Taghkanic rocks, or perhaps as the *Taghkanic System*. . . Considering them for the present, as belonging to the upper portion of the Primary, the Taghkanic rocks will be composed first of a peculiar talcose slate, or a magnesian slate in part; in other parts, it is plumbaginous, which strongly soils the fingers. . . Second, of white, gray and clouded limestone, varying in texture from fine to coarse-granular, often interlaminated with slate, the latter often merely coloring the limestone, so as to impart that clouded appearance . . . Third, of granular quartz, or a sandstone generally silicious and of a brown color . . . The whole *Taghkanic System* is clearly stratified, and is wholly unconnected with gneiss, serpentine, granite, sienite, steatite or hornblende . . . "

This distinct announcement of the Taconic System, it will be observed, appears in a volume printed in March, 1842. It must have been drawn up, probably, some months previously. Professor J. D. Dana, by a slip extraordinary for him, has quoted a passage from Mather's Fifth Annual Report[†], the meaning of which is that the writer, on January 20, 1841, (Dana says Febuary 1, 1841), regarded the "granular quartz" (embraced in the Taconic) as simply "the Potsdam sandstone in a metamorphic state", and the associated "granular limestones" as belonging to the same geological epoch", and that "the rocks generally along the eastern border of New York, and probably all the rocks from the New York State line east to the Connecticut valley are similar". But these, it appears, were not Emmons' views on the first of February, 1841. The conception of the Taconic system was not originated in the brief period between this date and January 1, 1842—the date of Emmons' final report. The citations already made from the geology and map of Berkshire county show that the body of rocks between the Primary granites, gneisses and schists, and the Transition rocks above, had been isolated eighteen years before, though at that time designated "Upper Primary". If Emmons made no mention of them in his annual reports, it was because they were not embraced in his district. In a final report, however, he tells us he felt constrained to carry into effect a plan formed in the beginning of the survey, "to furnish the materials necessary for a complete work on the New York rocks" and to make "this volume distinct from, and independent of, the reports of the other districts"* In another connection he informs us that the conception of the Taconic dates from 1838.* *

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[*] *A Gazetteer of the State of New York*, etc., Albany, 1842. J. Disturnell. March, 1842, p. Attention has been called to this and other early literature bearing on the Taconic system, by Lieut. A. W. Vogdes, in the *American Geologist*, vol. II, 1888, pp. 352-55.

[†] *Amer. Jour. Sci.*, III.XXXVI.411, beginning."The granular quartz of Bennington",&c.

In his Final Report on the geology of the Second District,† Dr. Emmons gave the following classification of the Primary rocks:

I. UNSTRATIFIED.	II. STRATIFIED.	III. SUBORDINATE.
1. Granite	1. Gneiss.	1. Porphyry.
2. Hypersthene rock.	2. Hornblende.	2. Trap.
3. Primitive limestone.	3. Sienite.	3. Magnetic, and
4. Serpentine.	4. Talc or Steatite.	4. Specular oxide of iron.
5. Rensselærite.		

The granites are recognized as erupted at different epochs. The hypersthene rock contains disseminated grains and extensive beds of magnetite (p. 222). The primitive limestone is still regarded as unstratified and igneous in origin (pp. 38, 225). Adverse opinions are examined, and new evidences adduced. Serpentine is also alleged to be never stratified, and to have been erupted, probably, at different epochs (pp. 69, 70). Yet it never occurs in dikes or veins, and causes no alteration in contiguous rocks. The same opinions are entertained of Rensselærite (p. 74). "The term sienite is applied to a stratified rock composed of feldspar and hornblende" (p. 80). The magnetic and specular oxides of iron are regarded as of igneous origin (p. 97). Of the origin of the stratified primary rocks nothing is here recorded.

The seventh chapter of this volume (pp. 135–164), is devoted to the "Taconic System," though none of the rocks have been observed to occur in the Second District of New York. "A large portion of its rocks or masses are interlocked between the New England or primary ranges upon the east, the most important of which is the Hoosick mountain, and the Taconic (range), with the more westerly abrupt hills, upon the west—or the eastern border of the New York Transition system." On each side, the rocks partially blend with the contiguous systems. The lower limit of the Taconic system is the upper limit of the Primary. The statement that "these rocks belong to the earliest deposits" (p. 141) would imply that gneiss (of the Primary) is not regarded as sedimentary in origin[*]. The upper limit of the Taconic system is the Potsdam sandstone—which at this epoch was regarded as the base of the fossiliferous series, or at least of the Silurian series.

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*_Report, Second Dist._, 1842, p. 135.

**_American Geology_, Pt. II. pp. 5 and 6.

†_Geology of New York_, Part II, 1842, p. 23. This was published May 26, 1843.

The formations here embraced in the Taconic system are the following, in descending order:

5. Stockbridge limestone, coarse granular and of various colors.
4. Granular Quartz rock, generally fine grained and brown, but sometimes white, granular and friable.
3. Magnesian slate having a soft feel. Principal mass of Taconic mountains (p. 153). Perhaps repeated in Greylock mountain, on the east of the Sparry limestone.
2. Sparry limestone.
1. Taconic slate, at the western base of the Taconic range, adjacent to the Hudson River shales.

The order of superposition, however, is not regarded as settled (p. 150).[†]

This is what Dana calls Phase I.

It is difficult to appreciate the reasons given by Dr. Emmons for placing his Taconic slate at the bottom (supposing this is what he means)—even in the light of his own section from Adams, Massachusetts, westward to the Champlain rocks of New York (given on p. 145). It is true the beds have a general dip eastward, giving the "Taconic slate" the appearance of dipping under all the other members; but the "Taconic slate" lies contiguous to the Champlain rocks, and even extends under them, though apparently by an overslip of the latter.

It is a singular inconsistency of Dr. Emmons, that in explaining the distinctions of the four limestones from the Primary to the Champlain, he expressly ranges the "Sparry limestone" above the "Stockbridge limestone" (p. 142)—an order which he was destined later to accept for the whole Taconic series. Similarly, (p.

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[*] "Dividing the rocks into two classes, the primary and sedimentary" (p. 290) he says. elsewhere. See also p. 416.

[†] There are some indications that the order intended by Emmons is the reverse of this. So Mr. Marcou has understood him, in "The Taconic system and its position in stratigraphic geology" (*Proc. Amer. Acad.*, xii. 174-256, 1885.)

142) he places the "magnesian slates" below the "fine aluminous slate ("Taconic slate,") an order which he immediately, but with apparent unconsciousness, reverses (p. 144) and, though somewhat hesitatingly, defends (p. 147).

The Stockbridge limestone must be distinguished from the Primary limestone below, and the Sparry limestone must not be confounded with a silicious limestone occurring in the "Champlain group" above. Similarly, "the "Magnesian slate" must be distinguished from the lower Talcose slate of the Primary, and the Taconic slate must not be confounded with the shales and slates of the Hudson river. The Taconic rocks are entirely destitute of fossils; but "they furnish us with a knowledge of that state which immediately preceded the existence of organic beings" (p. 164). They are regarded as "equivalent to the Lower Cambrian of Professor Sedgwick," "the upper portion being the lower part of the Silurian system."

In the "Tabular Views" of the sedimentary rocks of New York (p. 429), the members of the Taconic system are given as follows:

4. **Granular Quartz** [=Potsdam sandstone.]
3. **Stockbridge Limestone** [=Blue limestone of Hudson Valley.]
2. **Magnesian Slate** [=Slates of the lowest formation of the Appalachian System.]
1. **Taconic Slate.**

I have placed at the right in brackets the equivalences of the Taconic members as maintained by professor H. D. Rogers, in 1844.*

It will be noticed that the relative positions of the Granular Quartz and Stockbridge limestone here are the reverse of those given near the commencement of this report. Also, the Sparry limestone is omitted.

1844. Dr. Emmons issued a thin quarto volume entitled "Taconic System," and dated December 2, 1844, containing the results of the previous two years of study. The Taconic system appears with important changes and an extension of area. The contents of the memoir were exactly reproduced (except the Preface) in his Report on the Agriculture of New York.†

1846. In the first volume of his Report on the Agriculture of New York,‡ he devotes the fifth chapter (68 pages) to a fresh discussion of the Taconic system. Stimulated by the opinion of the brothers Rogers, accepted by Mather, E. Hitchcock and Dr. Samuel L. Dana, that the Taconic rocks were merely metamorphic conditions of the lower members of the New York or Appalachian system, he resumes, with new facts, a presentation of evidences sustaining his former positions, 1st, that the Taconic rocks are "inferior to the Champlain division of the New York system, or the lower division of the Silurian system of Murchison (p. 55); 2d, That they are a series of sediments reposing directly on the Primary system; 3d, That they contain previously unknown organic remains; 4th, That the lithologic members of the Taconic system have a different order of arrangement from that found within the New York system, and are much thicker than those to which they have been supposed equivalent in that system. The members of the system, as now recognized, are as follows:

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* In May, 1844, Prof. H. D. Rogers returned to a discussion of the Taconic system, in his presidential address before the Association of American Geologists and Naturalists at Washington (*Amer. Jour. Sci.*, xlvii, 137, 247, 440). He seems to have been the first to suggest that the Potsdam sandstone might not be the absolute base of fossilization among American rocks.

† *The Taconic System, based on observations in New York, Massachusetts, Maine, Vermont and Rhode Island.*

‡ *Agriculture of New York*, vol. 1, 1746, p. 55.

6. Black slate (hitherto included in Taconic slate), with *Atops trilineatus* and *Elliptocephalus asaphoides.* I.
5. Taconic slate (with seven subdivisions), including Hoosick roofing slates with *Bucoides* and *Nereites.* III.
4. Sparry limestone (of Eaton). II.
3. Magnesian slate of Taconic and Saddle mountains.
2. Stockbridge limestone, in the Hoosick and Housatonic valleys, and extending to Sing Sing.
1. Brown sandstone or Granular Quartz, with four subdivisions.

This is what Dana calls Phase II.

The Sparry limestone is here replaced, the Black slate is separated from the Taconic slate, and the whole series is turned upside down. This order is now in accordance with the indications of the section given on page 145 of his Report on the Second District, and conforms with the theory of an overturn, as maintained by H. D. Rogers.

In this volume, the Taconic is recognized in Rhode Island, in Maine and in Michigan.

In another publication of about the same date* he makes a historical remark on the origin of the Taconic system, referring to the article in Disturnell's State Register. "In making up our notes for this object," he says, "we found it necessary to fix upon some general subdivisions of the rocks belonging to the State. We drew up an abstract of the plan, and submitted it to the criticism of the Rev. Prof. Dewey, of Rochester. . . . Professor

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**American Quarterly Journal of Agriculture and Science*, vol. iv, 1846, p. 202.

Dewey approved of the division proposed, in the main. It resulted in separating the rocks in the vicinity of the Taconic range, both from the Primary and the New York Transition, as we then called them.

1848. Professor James Hall having described[*] *Atops trilineatus* of Emmons under the name of *Calymene beckii*, and referred it to the Hudson River group, and having also described in the same work (p. 256) *Elliptocephalus asaphoides* under the name of *Olenus asaphoides*, and referred it likewise to the Hudson River group (see especially Hall's foot-note, p. 257) professor Emmons, "with other specimens more perfect" presented to the American Association, a new and detailed description of *Atops trilineatus*, and a parallel description of *Triarthrus* (*Calymene*) *beckii*[†] pointing out what appeared to be important differences[‡]. He also discussed *Elliptocephalus*, and indicated technical distinctions between that genus and *Olenus* and *Paradoxides* (p. 18). In the same connection he repeated that the tenability of the Taconic system rested on structural and mineralogical evidence "far more important than the presence or absence of certain fossils"—meaning evidently, these fossils.

1855. In his "American Geology," the second part of which appeared this year,[||] the Taconic system receives a new presentation. The following is a synopsis of the System as then understood:

Upper Taconic.	Black slate of Bald mouniain,	I. Cambrian.
	Taconic slate,	III. I. Hudson slates and Cam.
Lower Taconic.	Magnesian slate,	III. Hudson slates.
	Stockbridge L. includ'g Sparry L.	II. Lower Silurian.
	Granular Quartz.	I. Cambrian.

(I have added on the right, the equivalences as laid down in 1888, by professor J. D. Dana).

This is styled by professor Dana, Phase III; but the only change made since Dr. Emmons' last publication is the omission of the "Sparry Limestone," as in the "Tabular View," at the end of his Report on the Second District—this being merged in the "Stockbridge Limestone,"—and the recognition of a division of the system between the fossiliferons and the unfossiliferous portions—giving us "Upper" and "Lower" Taconic. There were two reasons for inverting the order as originally given : 1st, evidence of an overturn, as all along argued by Rogers, and as shown by the diagram given by Emmons himself ; 2d, the discovery of fossils in the Black slate, which Emmons had always merged in the Taconic slate, or had closely associated with it (*Ag. Rep.*, *63*). Thus the Black and Taconic slates now stood at the top, but their close chronological association was an erroneous assumption—the former only belonging truly to the sub-Potsdam series. As Dr. Emmons excluded the Potsdam sandstone from the Taconic, and as the Granular Quartz has proved to be Potsdam sandstone, the Black slate was all that he had thus far really brought into the sub-Potsdam Taconic. This Black slate of Bald mountain, Rensselær county, was now the only imperishable nucleus of the Taconic system as conceived—however Dr. Emmons believed. The so-called Lower Taconic was pronounced azoic.

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[*] *Palaeontology of New York*, vol. i. p. 252., pl. lxv. figs, 4a-c.

[†] *Proc. Amer. Assoc.*, 1848, pp. 16-19.

[‡] In his judgment of lack of identity, he had been sustained by S. S. Haldeman, chairman of a committee of the Association of American Geologists and Naturalists a pointed to consider the question (*Amer. Jour. Sci.* II, v. 117, 1848). This judgment fessor Hall opposed (*Amer. Jour. Sci.* II, v, 322. 1848.)

[||] *American Geology.* Part II, 850 pp., Albany, 1855, pp. 1-122.

The following points taken from the "American Geology" (p. 122) embody the most important features of the system as then understood by its author: 1. "Its series divided into groups are physically unlike the Lower Silurian series; 2. "It supports unconformably at numerous places, the Lower Silurian rocks." 3. "It is a vital system, having been deposited during the period when organisms existed"; 6. It "carries us back many stages further in time, when life gave vitality to its waters, than the Silurian." To the Bald mountain locality of trilobites he here added one in Augusta county, Virginia, from which he described *Microdiscus quadricostatus*. He also described four marine plants, 22 graptolites and six molluscs.

Keeping in mind the black slate of Bald mountain, which had yielded two species of trilobites regarded by Emmons as sub-Potsdam in age, though described by Hall as of Hudson River age, it is interesting to note the discovery, about this time, of other trilobites in the Black slates of West Georgia, Vermont, lying within the region claimed by Emmons as Taconic. These falling, after two years, into the hands of professor Hall, were also described by him* as belonging to the Hudson River group. By this authority the beds were thus made equivalent to the Bald mountain Black slate. The names given these trilobites were *Olenus thompsoni*, *O*, *vermontana* and *Peltura holopyga*, now determined by Walcott as *Olenellus thompsoni* Hall, *O.* (*Mesonacis*) *vermontana* Hall sp. and *Bathynotus holopyga* Hall (*Amer. Jour. Sci.* III, xxxvii, 389, May, 1889). These were new accessions to the real

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**Twelfth Ann. Rep. New York Regents*, 1859, 59-62. On the age of the rocks see *Pal. N. York*, vol. III, p. 94; compare also *id.*, p. 83.

Taconic, for, though made Silurian by Hall, they were recognized by Barrande as primordial or sub-Silurian types. A real sub-Potsdam Taconic existed, therefore, in 1854, in Rensselaer county, New York, and in West Georgia, Vermont, not to mention Augusta county, Virginia. That fact was embraced in Dr. Emmons' claim.[*]

1859. We have no documents of this date from the pen of Dr. Emmons, showing his use of these primordial trilobites as vouchers for the existence of a real Taconic system. We find no recorded views from him on the publication made by Prof. Hall in 1859; but in his Manual of Geology[†] (p. 88) the preface of which is dated May 1, 1859, a large trilobite is figured under the name of *Paradoxides brachycephalus*, which, as suggested by professor C. H. Hitchcock in 1881,[‡] is identical with *Olenus thompsoni* Hall.

This publication antedates that of the *Twelfth Regents' Report.* The evidence is, therefore, that independently of work done by others in Vermont, and before their results were published, Dr. Emmons had become acquainted with, delineated and published sub-Silurian trilobites within the Vermont area over which he had extended his asserted sub-Potsdam Taconic system. The Georgia slates now beginning to yield the palaeontological evidence of their age, were part of the "Primitive argillaceous slate" of professor Dewey;[§] the "Primitive argillaceous slate" of Dr. E. Hitchcock;[**] the "Black slate" and "Taconic slate" of Dr. Emmons in various publications on the Taconic system.

1860. However, in a note at the end of the second edition of his Manual of Geology (p. 280) he says: "The slates or shales referred to (in the *Regents' Report* for 1859) in northern Vermont, as constituting a new series above the so-called Hudson River group, instead of ranking thus high in the geological scale, are really sub-Silurian, as is fully proved by the overlying calciferous sandstone.

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[*] The Taconic system was maintained in the *Report on the Geological Survey of North Carolina.* 8 vo. 1856, pp. 49-72--reviewed in *Amer. Jour. Sci.* II, xxiv, 427-430.

[†] *Manual of Geology.* By E. Emmons. 290 pp. 8 vo. Philadelphia. 1860.

[‡] *Geology of Vermont*, vol. 1. 367.

According to Prof. Hall, the whole of the XIIth *Regents' Report* was published previous to Sept. 20, 1859. Mr. Billings gives Oct. or Nov. for the date of publication (*Canadian Naturalist*, vi, 316) though the date on the title page is March 15. 1859—evidently the date at which the printing began. This document purports to be "some of the results of investigations made during the years 1855, '56, '57 and '58 by James Hall" and a note states that they "are already printed in the third volume of the *Palaeontology of New York.*" The transmission of this volume to the governor, nevertheless, is dated September, 1859." showing that though "printed," it was not published earlier than the *Twelfth Regents' Report*.

[§] *Geological Map of Berkshire, Mass; Columbia and Rensselaer counties, N. Y.*, Amer. Jour. Sci., viii, 124.

[**] *Geological Report of Massachusetts*, 1832.

. . . We now know the following trilobites, all of which belong to a slate beneath the Calciferous, viz: *Atops punctatus*, *Elliptocephalus* (*Paradoxides*) *asaphoides*, *Paradoxides Thompsoni*, *P. Vermontanus*, *P. macrocephalus*. *P.* (*Pagurus*) *quadrispinosus* and *Microdiscus quadricostatus*."

This extension and validity were given the Taconic system during the life of Dr. Emmons, and almost wholly through the persistence, ability, and force of his own efforts. The geologists of the country, save Vanuxem, Jewett and Billings, were unitedly against him. The most prominent palæontologist of the country had referred the Georgia trilobites to the upper part of the Hudson River group. The distinguished structural geologist of Canada, Sir William Logan, had rendered his testimony that the shales affording the fossils were "part of a series of strata which he is (was) inclined to rank as a distinct group above the Hudson River proper.[*] Only one authoritative voice was raised in vindication of Dr. Emmons' long contested claims. That voice came from across the ocean, and almost in tones of reproach for American palæontology, in failing to recognize the principles of order which it had professed to recognize in the succession of organic life, gave utterance to the sentiment: "Si le Dr. Emmons fait encore de la géologie c'est pour lui une belle occasion pour réproduire ses anciennes observations et ses idées avec plus de succés q'en 1844.[†]

No public documents relating to the Taconic, of later date than 1860, issued from the pen of Dr. Emmons. He went to North Carolina in September, 1860, as State Geologist, and remained within the Confederate lines during the civil war, "until he died, in 1863, at his plantation in Brunswick county, on the first of October". Mr. Marcou, however, maintained a correspondence with him until January 28, 1861, and from these letters I quote a few passages.[‡]

In a note dated Raleigh, Nov. 10, 1860, he says : "I do not think him (Barrande) right in maintaining that his Primordial Group is a part or parcel of the Silurian . . . The Lower Silurian is strictly unconformable to every part of my Taconic series." Writing the next day, he continues : "Perhaps I did Barrande injustice. . . I find that after all, his Primordial Group is only Lower Silurian. I conceive we have exactly his Primordial Group in the band of slates containing the *Paradoxides.** On the 28th of December, referring to a communication rejected by the editor of the *American Journal of Science*, in which were embodied some comments on the Huronian system of Logan, he says: "I claimed that the Huronian was only the Taconic system." On January 23, 1861, he writes: "It was ten years ago, I think, when I claimed Logan's Huronian system as nothing more than the Taconic. . . The acknowledgment of the Primordial of Barrande in this country (referring to some concessions of Sir William Logan)† is really one of the finest and best facts in geology, making a co-ordination of American and European rocks so complete and harmonious; I think of nothing I have said or done in this matter; I look upon the harmony of the systems; they are truly worth dwelling upon."

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[*] Twelfth Report N. Y. Regents, p. 62, note.

[†] Letter of M. Barrande to M. Marcou, 14th Aug., 1860. (*Proc. Amer. Acad.*, 1885. p. 182) "On the Primordial Fauna and the Taconic System of Emmons." Also, in part, *Proc. Boston Society Nat. Hist.* vii, Dec. 1860, 369-375.

[‡] The letters are published, with much other correspondence, in *Proc. Amer. Acad.*, xii, 1885. pp. 181-224.

In reference to M. Marcou's proposal to include the Potsdam sandstone within the Taconic, Dr. Emmons writes, January 28, 1861: "Let me declare once for all, that I have not the slightest objection to your view. . . If you believe you can make out a good case with the Potsdam anywhere, I never shall object, for I have no wants except truth."

These noble sentiments close the correspondence, and constitute, so far as I know, the last utterance of Dr. Emmons which passed the lines of a country so soon to become the theatre of bloody war.

Let us now consider the form which the Taconic system had assumed during the lifetime of its author:

Upper Taconic.	Potsdam sandstone (suggested by Marcou, assented to by Emmons).	I. Cambrian.
	Black slate of Bald Mountain and Georgia slates of Vermont.	I. Cambrian.
	Taconic slates.	III. Hudson slates and I. Cam.
Lower Taconic.	Magnesian slate.	III. Hudson slate.
	Stockbridge limestone, including Sparry limestone.	II. Lower Silurian.
	Granular quartz.	I. Cambrian.

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*This looks like an admission that Emmons' *Paradoxides* band was Lower Silurian—against which he contended. But though Primordial was Silurian in the extended sense in which Barrande used the term, it was beneath the Silurian as Emmons conceived it. On the previous day he had declared Barrande's Primordial *not* properly Silurian.

†About this time, in a letter to Barrande, dated Dec. 31, 1860, Sir W. E. Logan wrote: "Professor Emmons has long maintained . . . that rocks in Vermont which in June, 1859, I for the first time saw and recognized as equivalent to the magnesian part of the Quebec group, are older than the Birdseye limestone: the fossils which have this year been obtained at Quebec, pretty clearly demonstrate that in this he is right. It is at the same time satisfactory to find that the view which Mr. Billings expressed to you in his letter of the 12th, July, to the effect that the Quebec trilobites appeared to him to be about the base of the second fauna, should so well accord with your own opinions, and that what we were last spring disposed to regard at Georgia as a colony in the second fauna should so soon be proved, by the discoveries at Quebec, to be a constituent part of the Primordial Zone." This, says Barrande (*Documens anciens et nouveaux*, etc. *Bull.* 4 Fev., 1861, p. 320) "is a formal recognition by Sir William Logan, of the Taconic System at the base of the Silurian."

On the right are the parallelisms established by Dana, Walcott and others. The Table shows the Taconic system left by its author in state of incompleteness—even confusion. We find three members whose true positions are above the Potsdam sandstone. But we find also three members whose positions are admitted to be sub-Potsdam—as maintained by Emmons. The mal-position of the Stockbridge limestone was an error of exactly the same magnitude as that of the geologists who would identify the Granular quartz with the Potsdam sandstone, or would make the Black slates of Georgia synchronous with the Hudson River shales. Our science was then in a comparatively crude state, and none of these errors need surprise us. We have ascertained that a real sub-Silurian system exists, and that Dr. Emmons fixed upon three if not four of its members. Such are the facts. Geologists will differ as to the question whether such a degree of success entitles Dr. Emmons to a recognition of the name proposed by him for the real system whose existence he mentally apprehended so well, but whose form he defined so imperfectly.

It is intended to pursue the later history of opinion concerning the Taconic system, as, with the progress of science, the question became more and more palæontological; and if not yet regarded as settled, the discussion is proceeding mainly on palæontological grounds. The principal papers published in the controversy, since the close of the era of the founder—about 1860, will, unless previously quoted, be found cited in the subjoined note.

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1861. Barrande. J.
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1861. Hunt, T. S.
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The Taconic and Lower Silurian Rocks of Vermont and Canada. *Proc. Bos Soc. Nat. Hist.*, Vol. viii. pp. 229-253.
1862. Marcou, Jules
Liste additionelle des fossiles du terrain Taconique de l'Amérique du Nord. *Bull. Soc. géolog. de France*, vol. xix p. 746 Paris.
1862. Marcou, Jules
Letter to Mr. Joachim Barrande on the Taconic Rocks of Vermont and Canada, Aug. 1862. pp. 1-15. Cambridge. Mass.
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1864. Marcou. Jules
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1865. Logan, W. E.

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An Account of the Discoveries in Vermont Geology of the Rev. Augustus Wing. *Amer. Jour. Sci.* III. xii. pp. 332-347; 405-419; xiv. pp. 36-7.

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On the Relations of the Geology of Vermont to that of Berkshire. *Amer. Jour. Sci.* III., xiv, pp. 37-48; 132-140; 202-207; 257-264.

1878. Prime, Frederick, Jr.

On the Discovery of Lower Silurian Fossils in Limestone associated with Hydromica Slates, and on other Points in the Geology of Lehigh and Northampton counties, Penn. . *Amer. Jour. Sci.* III, xv, 261-269.

1879. Dale, T. Nelson, Jr.

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1879. Dana, J. D.

On the Hudson River Age of the Taconic Schists, and on the dependent Relations of the Dutchess county and Western Conn. Limestone Belts. *Amer. Jour. Sci.* III. xvii. 375-388; xviii. 61-64.

1879. Dwight, W. B.

On some Recent Explorations in the Wappinger Valley Limestone of Dutchess county, N. Y., *Amer. Jour. Sci.* III. xvii. 389-393.

1879. Whitfield, R. P.

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1880. Lesley, J. P.

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Note on the Trilobite, *Atops trilineatus* of Emmons [Holding it distinct]. *Amer. Jour. Sci.*, III. xix. 152-3.

1880. Dana, J. D.

List of Papers on the Taconic System [as at first defined by Emmons] [with statements of points]. *Amer. Jour. Sci.*, III. xix. 153-154.

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On the Western Limits of the Taconic System. *Amer. Jour. Sci.*, III. xix. 25-28

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Geological Relation of the Limestone Belts of Westchester County, N. Y., *Amer. Jour. Sci.*, III, xxii, 313-315-327-335.

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1884. Hall, James.

On the Hudson River Age of the Taconic Slates. [Notice of by Dana]. *Amer. Jour. Sci.*, III, xxviii, 811-312.

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On the Taconic System of Emmons [Compiled as an expression of opinion.] *A Geologist*, ii, 215-219, with Note by N. H. Winchell, 220-224.

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Some Forgotten Taconic Literature. *Amer. Geologist*, ii, 352-355.

1888. Walcott, Charles D.
The Taconic System of Emmons, and the Name Taconic in Geologic Nomencla ture. *Amer Jour. Sci.* III, xxxv, 229-242; 307-327; 394-401.

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1889. Howley, James P.
The Taconic of Eastern New Foundland. *Amer. Geologist*, iv, 121-125.

1889. Walcott, C. D.
Stratigraphical position of the *Olenellus* Fauna in North America and Eu *Amer. Jour. Sci.*, III, xxxvii, 374-392; xxxviii, 29-42.

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Recent Explorations in the Wappinger Valley Limestone, No. 7. In the lerton Fishkill Limestone Belt; also in a Belt near Rhinebeck. *Amer. Sci.*, III, xxxviii, 139-158.

1890. Dwight, W. B.
Fossils of the western Taconic Limestone, in the eastern part of Dut county, N. Y. (Announcement.) *Amer. Jour. Sci.*, III, xxxix, 71.

DOUGLASS HOUGHTON.

1831. Dr. Houghton's earliest record in respect to the rocks of Michigan is found in his report to the Secretary of War as Botanist of Schoolcraft's Expedition.* Speaking of the copper of lake Superior, he says: "After having duly considered the facts which are here presented, I would not hesitate to offer as an opinion that the trap rock formation was the original source of the masses of copper which have been observed in the country bordering on Lake Superior; and that at the present day, examinations for the ores of copper could not be made in that country with hopes of success, except in the trap rock itself; which rock is not certainly known to exist in any place upon lake Superior other than Kewena point." This opinion on the source of the native copper he had subsequently abundant opportunity to confirm, though opposed by much scientific incredulity.

1840. In his Third Annual Report on the geology of Michigan, dated February 3, 1840, summarizing observations of 1839, Dr. Houghton treats of the "Upper Peninsula." Under the head of "General Geology of the South and Southeasterly Part of the Upper Peninsula,"† after describing the distribution of the "Primary rocks" in Michigan, he says: "The immense Primary region of which the line described may be considered as it were, a single point, stretches nearly continuously, many hundred miles northwesterly, skirting a portion of the shores of lake Superior, and in conjunction with the trap rocks, constituting the highlands between that lake and lake of the Woods. From these highlands it stretches a little east of lake Winnipeg, far to the northwest, finally constituting the immense "barren grounds" of the British Possessions. It is also well known that this range of primary rocks stretches in an easterly direction through the interior of the upper province of Canada" (p. 11).

This is the earliest general location of the eastern nucleus of the continent.

1890. Marcou, J.
The Lower and Middle Taconic of Europe and North America. *Amer. Geologist*, v. 357-375; vi, 78-102, 222-233.

1890. Winchell, N. H. and H. V. Winchell.
The Taconic Ores of Minnesota and Western New England. Read before the Geological Society of America, Aug. 19. *Amer. Geol.* Nov. 1890.

1890. Winchell, N. H.
What Constitutes the Taconic Mountains? Read before Sec. E. Amer. Assoc. Adv. Sci., Aug. 22, 1890 *Amer. Geol.*, vi, 247.

*Nov. 14, 1831. Also Henry R. Schoolcraft, *Discovery of the Source of the Mississippi* New York, 1834, pp. 287-292.

† *Senate Document* No. 8, 1840, p. 10.

Some further but disconnected quotations will be introduced.

"On the mainland at these 'narrows' [the place where the current of Ste. Marie's river meets the slack-water of lake Huron] and extending for several miles, the knobs are composed of compact greenstone, occasionally partaking of a sub-slaty character, and under which circumstances, the rock bears a close analogy to some of the varieties of primary argillite."

"On the northern part of the island of St. Joseph, a fraction of the southeastern part of Sugar island, and a portion of the main land on the east, the place of the hornblende rock is supplied by granular quartz rock, usually white, but sometimes passing to a reddish or deep red color."

"In the range of hills bounding the easterly side of Great Lake George, talcose slate was observed, but to what extent it exists I am unable to say" (p. 13).*

It appears that Dr. Houghton's conception of "Primary rocks" was rather broad. The granular quartz rock mentioned is now known to be a westward extension of the "Huronian" quartzites of the Thessalon valley in Canada. The "talcose slate" on the other hand, probably belongs to the Marquette iron-bearing series which by the present writer has been suggested to be an older system than the Huronian. It is worthy of note also, that Dr. Houghton reports the "Lake Superior sandstone" as resting "against and upon the Primary range of the Ste. Marie's river." That is, at one point the "talcose slates" (Marquette series) rest in contact with the gneisses; at another, the overlying quartzyte (Huronian) extends over to the gneiss; and at another, the still higher sandstone (Palæozoic) reaches over to the gneiss. Thus, it is unsafe to conclude that the formation resting on the gneiss at any particular spot is the one historically next in order of age.

1841. In his report for the following year, † he continues his description of the Northern Peninsula. His conception of Primary rocks appears more restricted, for he says they "are chiefly granite, syenite and syenite granites." (p. 15.) After describing the vast development of "Trap Rocks," he recognizes a group designated "Metamorphic Rocks." "Flanking the Primary rocks on the south," he says, "is a series of stratified rocks consisting of talcose, mica and clay slates, slaty hornblende rock and quartz rock; the latter rock constituting by far the largest proportion of the whole group." These represent the group of rocks in the Menominee region, which Dr. Emmons so eagerly accepted as representatives of the Taconic system in Michigan.

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* In view of the recent extensive employment of "field stones" in some parts of the state, in the walls of substantial structures, the following quotation from this report possesses interest: "In the immediate vicinity of the surveyed line of the Ste. Marie's canal, transported masses of granite, hornblende, sienite and quartz rock abound, and they may be economically employed for the construction of the proposed locks, and will make an enduring structure." (p. 15).

†Senate Document No. 16, 1841.

The following is an interesting early notice of the mode of occurrence of serpentine. "In traversing the country southeasterly from Little Presqu' ile, the point referred to as the most southeasterly prolongation of the granite, this last rock passes almost insensibly into a serpentine rock* which has a regular jointed structure, sometimes approaching to stratification; continuing in the same direction, we find a series of hornblende slates, talcose, mica and clay slates, resting against the serpentine rocks; and still farther to the southeast, the rock becomes almost uniformly quartz. The rocks of this group dip irregularly to the south and southeast, while the cleavage of the slate is very uniformly to the north," (p. 17.)

A gradual passage from granite to "greenstone" is noted as follows: "As we proceed northwesterly from the southeast boundary of the Primary, over the several broken ranges of hills, we find the character of the rocks in mass almost imperceptibly changing. The quartz as a mineral gradually forms a less important part, and it finally almost wholly disappears, leaving a binary compound of feldspar and hornblende, which then assumes a granular structure, constituting greenstone. The intermediate rock between the syenite and greenstone ranges may not inappropriately be called a syenitic greenstone," (p. 23.)

The granitic rocks are intersected by dikes which can be traced continuously and with increasing abundance, into the greenstone masses, showing the granitic ranges to be the oldest (p. 24).

In reference to amygdaloids he says: "I am disposed to refer the origin of much of the amygdaloid rock to the fusion of the lower portion of the sedimentary rocks referred to, for the reason that as we pass south from the junction [receding from the sedimentary rocks] the amygdaloid rocks wholly disappear, their places being supplied by greenstone; and again, so intimately are they blended that it is frequently impossible to determine where the amygdaloid ceases and the upper sedimentary rocks commence. Fragments of the sedimentary rocks, the characters of which can be clearly recognized, are not of rare occurrence, imbedded in the amygdaloid rock, a circumstance which, although by no

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*The curious history of opinion concerning this much discussed rock is compiled by Dr. Wadsworth in *Bull. Mus. Comp. Zool.*, Geol. Series. I. pp. 60-65.

means conclusive, should not be overlooked in considering the subject" (pp. 27 and 28).

Of the conglomerate rock he says: "It may without doubt be considered as a trap tuff, which was gradually deposited or accumulated around the several conical knobs of trap during their gradual elevation" (p. 33). It is very variable in thickness. There is "scarcely a pebble of any other rock than trap." They are cemented by "a mixed calcareous and argillaceous cement more or less colored by iron, and exceedingly firm. The conglomerate is "imperfectly stratified in masses of immense thickness," in its maximum a little east of Montreal river, estimated at 5,260 feet. (pp. 34, 35).

The formation described as "mixed conglomerate and sandrock" "is made up of an alternating series of conglomerate and red sandstones which rest conformably on the conglomerate rock last described" and "in strictness should probably be considered as a member of the conglomerate itself" (p. 18). Its greatest observed thickness is 4,200 feet. The conglomerate beds resemble in all respects the underlying conglomerate, and the intervening sandstone beds are composed of the same materials, but are sometimes ripple marked, and were thus evidently deposited in shallow water. These sandstone beds are very distinct in composition from the "red" and "grey" sandstones higher in the series" (pp. 19, 37).*

It will serve to convey an idea of the extent of Dr. Houghton's researches in the Upper Peninsula to state that the *Exec., Doc.*, 1849-50, Part III, contains (p. 880), the following among Hough-

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*The "red sandrock" associated with "shales" is much more quartzose than the red intercalated with the conglomerate. It attains a maximum thickness of 650 feet. "On the southeast side of Keweenaw bay, near its head, an argillaceous rock appears" "evidently embraced in, or rather may be said to constitute a member of, the sandstone series." It is sometimes, "in the form of a slate," though usually it "closely resembles indurated clay." It can be cut with the knife, and the Indians have long used it as a pipestone. A similar rock appears at several other points in the interior. [These slates are shown by his notes of 1845, to pass under the sandstone.] The "Upper, or Grey Sandrock" is no part of the Lake Superior sandstone. While the latter dips northeasterly, this dips southeasterly, and is conformable with the overlying limestones. The "Grey Sandrock" forms a range of hills extending westward from Pt. Iroquois to the Pictured Rocks, where they abut upon the shore of the lake. It is Dr. Houghton's opinion, therefore, that the Pictured Rocks are a higher formation than the Red sandstone, generally contemplated as the "Lake Superior Sandstone" (19, 42.) The Lake Superior sandstone Dr. Houghton was at first inclined to parallelize with the "Old Red Sandstone" (*Report*, 1838); but, in a paper read before the Association of American Geologists in 1843, he assumed it as identical with the "New Red Sandstone" (*Amer. Jour. Sci.*, xlv, 160.) Later he synchronized it with the Potsdam sandstone of New York, and this view was embodied in his notes of 1845 (*The Mineral Region of Lake Superior*, 1846, by Jacob Houghton.) The statement is contained in a report by Bela Hubbard (page 118—compiled from Dr. Houghton's notes.) Also, *Executive Docs.*, 1849-50, pt. III, p. 839. The same was noted on the plats of 1845. See also the testimony of Foster and Whitney, *Report on the Geology of the Lake Sup. Land Dist.* Pt. II, p. 138, and *Proc. Amer. Assoc. Adv. Sci.* May, 1851, p. 23.

ton's results: 1. "A Geological Map of the Townships of the Northern Peninsula of Michigan subdivided by D. Houghton, D. S. in the year 1845." (This covers Keweenaw Point.) 2. "Geological Map of Township Lines in the Northern Peninsula of Michigan, surveyed by Wm. A. Burt, D. S. in the year 1845, for D. Houghton, under said Houghton's contract for surveys with reference to Mines and Minerals" (The region on Little Bay de Noquet and along the Escanaba river and to lake Superior.) 3. "Geological Map of a District of Township Lines in the Northern Peninsula of Michigan, surveyed by Wm. A. Burt in the year 1846." (Region between the Escanaba and Menominee rivers.) Also (p. 896.) 1. "Geological Map of a District east and west of the Ontonagon, subdivided by Messrs. Higgins and Hubbard under a Contract bearing date April 23, 1846" (From Portage lake to Carp river.) 2. "Geological Map of the District subdivided by Messrs. Hubbard and Ives, under Contract bearing date September 7, 1846." (The Region from Presqu' ile to L' Anse.) These six maps were produced under the system of combined linear and geological surveys inaugurated by Dr. Houghton. Thus nearly the whole of the Upper Peninsula had been geologically mapped before the signing of the contract with Foster and Whitney, and without including the results of Dr. Jackson's survey. Mr. Hubbard gives also, five handsomely drawn sections from lake Superior, across the country southward, besides five lithographed views.

The following is Dr. Houghton's latest view of the succession of rocks in the Upper Peninsula of Michigan :

6. Upper or Gray Sandstone (Houghton, 1841, pp. 19, 41) not conformable with next below.

5. Lower or Red Sandstone and Shales (Houghton, 1841, pp. 18, 37). Identified with Potsdam Sandstone.

4. Mixed Conglomerate and sandstone (Houghton, 1841, pp. 18, 35).

3. Conglomerate (Houghton, 1841, pp. 17, 33).

2. Metamorphic rocks (Houghton, 1841, pp. 16, 31). Quartzite, Argillite, Talcose and Clay slates, Mica slate.

1. Primary rocks (Houghton, 1841, pp. 15, 23). Granite, Gneiss, Syenite and Syenitic Granite.

Numbers 6 and 5 are probably both representatives of the New York Potsdam. Numbers 4 and 3 are the Keweenawan System of Chamberlin and Irving, and number 2 occupies the place of the Taconic system of Emmons.

EDWARD HITCHCOCK.

1833. In his Final Report on the Geology
Professor Edward Hitchcock enumerates, amo
ing rocks or groups of rocks mineralogically
wacke, Argillaceous slate, Limestone, Scapolit
Mica slate, Talcose slate, Serpentine, Hornble
all which are stratified; Greenstone, Porphyry
ite — which are unstratified. Of the Berk
thinks a part is "primitive, in the Wernerian
term, for it is interstratified with gneiss and n
But the mica slate in its westward extension
and the limestone less crystalline. Passing i
limestone assumes the character of Dewey's "t

"But a singular anomaly in the superposi
rocks above described presents a great difficul
strata of these rocks almost uniformly dip to t
newer rocks seem to crop out beneath the older c
charine limestone associated with the gneiss in
the range seems to occupy the uppermost place
as superposition is of more value in determini
of rocks than mineral characters, must we n
rocks as we go westerly from Hoosac mountai
to older groups? The petrifactions which so
and their decidedly fragmentary [fragmental
allow such a supposition to be indulged in f
impossible for a geologist to mistake the evide
almost every step, that he is passing from olde
soon as he begins to cross the valley of Be
west. We are driven then, to the alternative
that there must be a deception in the apparent
rocks from beneath the older, or that the whol
been actually thrown over, so as to bring the
bottom. The latter supposition is so improba
present admit it" (pp. 297-298). He then s
formities to have been produced — one at the
mountain between the gneiss and the quartz
farther west, in the valley of Berkshire. He
ties involved in the acceptance of such an e
compelled to adopt it provisionally. Moreo
sustained in this opinion by that of Dr. Emmo
lege, whose acuteness of observation and acc

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* Report on the Geology, Mineralogy and Botany and Zool
Edward Hitchcock. Amherst. 1833, Roy. 8-vo. pp. 700.

tion in the various departments of natural history are well known" (p. 300.

Professor Hitchcock frequently touches on questions of metamorphism. In his "Theoretical Considerations" on mica slate, after explaining the strict Wernerian view of the aqueous origin of all the primary rocks, and pointing out the improbability that so many different substances should crystallize out simultaneously from the same solution, he says:

"I am inclined therefore, to the theory which supposes that they were originally mechanically deposited from water, like the existing secondary and tertiary rocks, and that they have subsequently been subjected to such a degree of heat as enabled their materials to enter into a crystalline arrangement, without destroying their structure" (p. 350).

In reference to serpentine, professor Hitchcock advances some suggestions which were singularly in advance of his time. He speaks of prevailing divergences of opinion as to its nature and origin, and decides to describe it in connection with stratified rocks, though he finds it occurring unstratified as well as stratified. He mentions the various circumstances of its occurrence and adds:

"In all cases (except perhaps that at Newport) our serpentines are associated with talc, either pure and foliated, or as steatite, or chlorite slate, or talc and quartz. The two minerals (talc and serpentine) are intimately blended together, and pass into one another by insensible gradations, and in all the cases described by the writers above referred to, talc was present. Is it not natural then, to suspect that serpentine is talc, or talc serpentine, altered by heat? And since the talc is schistose, and the serpentine massive, the latter must have been produced from the former. . . It may be found that serpentine has been produced from various rocks which contained the necessary ingredients. But that heat has been employed in its production, cannot, it seems to me, be reasonably doubted" (pp. 372, 373).

In some "theoretical considerations" concerning gneiss, he says:

"Since gneiss is composed of the same simple minerals as granite, it is natural to infer that both must have had a similar origin. And especially are we led to such a conclusion, when we see in granitic gneiss a gradual passage from the one rock to the other. That granite has resulted from heat instead of aqueous deposition seems to me to be so well established that the opinion that imputes to it such an origin ought no longer to be regarded as hypothesis, but as legitimate theory. . . At present I shall assume that theory to be the correct one which supposes granite to have resulted from the melting down of other rocks; the fused mass having cooled so slowly as to present a confused crystallization. It is at least, a probable supposition, that the rock out of which it was produced was of mechanical origin, and consequently stratified. Now, if the central heat was not sufficient entirely to melt this stratified rock, yet it would be powerfully affected a considerable distance upward from the molten mass. The first in immediate contact with the melted portion would be partially fused, and hence give origin to granitic gneiss. Another portion might be converted into porphyritic gneiss; another, into lamellar; another intó schistose, etc. All the rock, we may suppose so near the fluid granite, and so long in contact with it, before cooling, that crystalline would succeed to a mechanical arrangement of all its ingredients, without losing the stratified disposition (p. 400).

In discussing the history of granite, professor Hitchcock states that he infers its igneous origin "from the inclined position of the older stratified rocks; from the manner in which it is intruded among the stratified rocks; from the mechanical effects which it appears to have exerted upon the stratified rocks in its immediate vicinity; from its chemical effects upon the surrounding strata, and from its crystalline structure, and the numerous crystallizations of other substances that have taken place in it" (pp. 509-515).

1840-1. The inversion of the strata of the Appalachian system is referred to again in his Elementary Geology.* Speaking of overturned strata in the Alps, he says:

"I have no small reason to believe that a similar folding and overturning of the strata have taken place on a vast scale in the United States. Along the western part of the Green and Hoosac mountains in New England, occur interstratified beds of gneiss, mica slate, talcose slate, clay slate, limestone and older Silurian rocks which are either perpendicular or have a high easterly dip; and yet the oldest members of the series are found along the eastern side of this belt, and the strata become newer and newer as we go westerly: that is, the oldest rocks lie apparently over the newer ones. These appearances present themselves nearly the whole distance from Connecticut river to Hudson river—a breadth of nearly fifty miles." He then describes the folding, overturn and denudation which would result in the present structure and surface aspects. "It appears further, from the Geological Reports of Professors Mather on New York, Henry D. Rogers on New Jersey and Pennsylvania, William B. Rogers on Virginia, and Troost on Tennessee, that these same

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***Elementary Geology.* The Preface to the first edition is dated August 1, 1840: that of the third edition, April, 1842. I quote from the third. 12mo., pp. xii 352.

rocks with similar inversion of their dip, occur in all those states, forming a considerable part of the Appalachian mountains; and that in fact, they extend almost uninterruptedly from Canada to Alabama—a distance of nearly 1200 miles; and if the above theory of the folding and inversion of this belt of rocks be correct in the latitude of Massachusetts, it is without doubt, true over this vast extent of country."[*]

The subject of inverted arrangement of the Appalachian strata was under careful consideration at this time, by the brothers Rogers, as well as by Dr. Hitchcock. The earliest enunciation of the conception of an inverted fold had been made by Dr. Hitchcock in 1833. His conception however, was not identical with that of the brothers Rogers. He spoke only of a single anticlinal, while the Rogers brothers saw a succession of anticlinals all tilted westward across the main mass of the Appalachians. In an address delivered in 1841, he said:[†]

"There is no small reason to believe, indeed, that on the western side of the continent, from Cape Horn, to the northern Arctic Ocean, *one vast anticlinal axis exists*, along the crest of the Andes and the Rocky mountains. Subordinate and perhaps intersecting systems of strata will undoubtedly be found along the extended line, but this appears to be the grand controlling, and probably the most recent, uplift of the continent. . . . The Appalachian range of mountains forms *another anticlinal ridge*, extending northeasterly through New England, and not improbably to Labrador" (pp. 264-265).

In the Elementary Geology before quoted, Dr. Hitchcock amplifies his defense of the metamorphic theory then recently introduced into geology by Alexander Brongniart. The main points stated are briefly these: 1. It shows why, amid so much evidence of chemical agency in the formation of the primary rocks, there is still so much proof of the operation of mechanical agencies. 2. It shows why silicates predominated in the earlier periods of the globe, and why limestone and carbon were more abundant at the later periods. 3. It explains the absence of organic remains in the primary stratified rocks. 4. It explains, too, the reason why carbon is much less abundant in the older than in the newer rocks. 5. It explains the imperceptible graduation of gneiss into granite" (pp. 259-61).

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[*] *Elementary Geology*. pp. 36, 37. The subject is also taken up in his Anniversary Address (cited below,) p. 268.

[†] First Anniversary Address Before the Association of American Geologists at their Second Annual Meeting in Philadelphia, April 5, 1841. *Amer. Jour. Sci.*, vol. xli, pp. 232-275.

In the Anniversary Address from which I have quoted, Dr. Hitchcock considers briefly the origin of dolomytes :

"As to that portion of this field [of dolomite and dolomitic limestones] which has fallen under my observation, I find that with one or two unimportant exceptions, all the cases of dolomitized limestone occur either in the vicinity of a fault or of unstratified rocks, or of the oldest gneiss. The pure dolomite is usually found where there is reason to believe extensive dislocations of the strata occur; and the marks of stratification in the limestone disappear nearly in proportion to the amount of magnesia which it contains, so that the pure dolomite shows scarcely any traces of it. I doubt not that similar conclusions will follow an examination of other parts of this deposit, so remarkably uniform in the geology of this continent; — and moreover, these conclusions correspond to the history of dolomitization in Europe. They seem to render probable the theory of sublimation from the interior of the earth."[*]

1859. In the Final Report of the Geology of Vermont,[†] Dr. Hitchcock, who assumed the responsibility, as he tells us, though most of the field work was done by others, takes up early in the report, the subject of "The Metamorphism of Rocks" (p. 22). In the following language he sets forth his general conception of the *modus operandi* of hypogeal metamorphism.

"If the globe was once in a molten state, the crust which first formed over its surface must have been some kind of unstratified rock. When it became coal enough to allow water to condense on the surface and form oceans, the waves would wear away portions of the rock, and deposit the fragments in the form of gravel, sand and clays. These by the action of internal heat might be hardened, and become conglomerates, sandstones and shales. If new beds of materials should be thrown upon these strata it would cause the internal heat to penetrate further upward into the conglomerates, sandstones and shales, and, by the help of water, render the rocks plastic and convert them from mechanical into crystalline rocks, without destroying the planes of stratification, though generally obliterating all traces of organic structures which they might have contained, and changing the laminated structure into foliation and cleavage. After all this, water may have acted mechanically on these strata, wearing them away, and forming other deposits of puddingstones, sandstones and shales. Meanwhile also, the internal heat working farther upward, as it certainly would by the accumulation of new beds of detritus, might melt over the lower beds of the strata, converting them into unstratified rock. And thus might the same materials have been subject to repeated and most thorough metamorphosis" (p. 22).

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[*] Amer. Jour. Sci., xli. 240.

[†] *Report on the Geology of Vermont, Descriptive, Theoretical, Economical and Scenographical.* By Edward Hitchcock, Edward Hitchcock, Jr., Albert D. Hager, Charles H. Hitchcock. 2 vols. 4to. Claremont, N. H., 1861. The preface is written by Dr. E. Hitchcock, and dated Oct. 1, 1859, and Oct. 2, 1860.

The writer then proceeds to an account of the "agents of metamorphism," heat and water, recalling the well known results of experiments and reasoning, and treats with considerable detail the evidences of "a former plastic condition of the rocks". He cites numerous observations, showing that rocks and rock-constituents must have been reduced to a plastic or semi-plastic condition, subsequent to their original consolidation, and so continued for a great length of time", In this connection he cites numerous instances of pebbles which have been elongated and flattened—some even at length being "converted into the silicious folia of schists, and the cement into mica, talc and feldspar". He refers to the pebbles near Newport, Rhode Island; others at intervals along the western side of the Green mountains, and especially a locality in Plymouth, Vermont, where pebbles occur under such forms as to indicate a state of plasticity. In Wallingford the beds of conglomerate thus altered alternate with beds of talcose and mica schist (pp. 28-38, 476). Some of the facts point toward the inference that schists and gneisses even may have originated from the extreme flattening and elongation of the pebbles of an original conglomerate, though as a fact, pebbles had not at that date been found actually occurring in gneiss. Dr. Hitchcock expects that such views would "be pronounced preposterous by able geologists*". In a syenitic rock, however, found in Vermont and Massachusetts, undoubted pebbles had been observed. Other facts have been noted by the writer: See, Conglomerates enclosed in Gneissic Terranes, *Amer. Geologist*, iii. 153-165; 256-261; *Sixteenth Ann. Rep.*, Minn. pp. 218-222, 334. He says:

"We define this rock as a conglomerate with a cement of syenite or granite, or as a syenite or granite with pebbles in it, sometimes thickly and sometimes sparsely disseminated". . . . "These facts certainly give great plausibility to the view which supposes granite and syenite to be often the result of the metamorphosis of stratified rocks" (pp. 40, 41; ii, 565, 566.*)

In connection with the discussion of metamorphism the writer

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*Dr. Hitchcock's expectation has found fulfillment in the dissent recorded by Dr. M. E. Wadsworth *Bull. Mus. Comp. Zool.*, Geolog. Series, 1; B. S. Lyman, *Proc. Amer. Assoc. Adv. Sci. 1866, p. 83.*

*See W. B. Rogers' views in opposition to those of Hitchcock stated in *Proc. Bos. Soc. Nat. Hist.* 1861 and *Amer. Jour. Sci.*, II, xxxi, 440-442, May, 1861.

reminds us of an inference which is too obvious to have fallen into such general forgetfulness. He says:

"Metamorphism shows us that the earliest formed rocks on the globe may have all disappeared. None of the first formed crust may remain. Or, if any of it is left, it would be impossible to distinguish it from subsequent formations. So that the idea of a primary granite or any other rock, in the strict sense of the term, has no foundation in nature" (p. 47.)

In close connection with this subject, we cite some passages from another chapter, touching the nature of foliation. Speaking of the gneissic rocks of Vermont, he says: "In certain districts the strata are exceedingly contorted, and the average dip and strike are the ones that we recorded. There is not a square mile of this rock in the State where there are not more or less of these irregularities. In a few instances, the difficulty of ascertaining the true position is so great that we have not attempted it."

After illustrating a striking particular instance of these contortions, he concludes:

"This state of things suggests two important topics: *First*, Do not these contortions prove that the layers that have suffered this twisting are the strata, and not the bedding of cleavage or foliation? For the beds between cleavage planes are rarely contorted. The strata may be contorted while the cleavage planes cross them with perfect regularity. In fact, the cleavage does not appear to have been produced until the strata had been quietly settled into their present positions, as a general thing." The *second* topic relates to the effect of contortion on calculation of thickness of terranes[*].

Speaking of the position of the "red sandrock" of northern Vermont," regarded by Emmons as belonging to the age of the Potsdam and Calciferous, Dr. Hitchcock says:

"Without an exception, it rests upon the Hudson River group. The stratigraphical evidence goes to show that the red sandrock is of the age of the Medina sandstone or Oneida conglomerate. This was the original view of Dr.Emmons, and has since been sustained by Professors C. B. Adams, W. B. Rogers[†] and W. E. Logan. It is certainly an objection to this view that the characteristic fucoid, *Arthrophycus Harlani*, of the Medina sandstone has never been found in it." (p. 340.) Compare A. D. Hager's description of "Red Sandrock mountains," (ii, 875.)

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[*] Geology of Vermont, p. 518.

[†] A communication is cited from W. B. Rogers, which is said to have been prepared for the *Amer. Assoc.* at Albany in 1851, but not published, in which this view is argued (*Geol. Vt.*, p. 326.) This view of Dr. Hitchcock, he states later in his Report, (p. 435) "has now been changed."

In reference to the "Quartz rock" of the older geologists—the "Granular quartz," of Emmons, the "Potsdam sandstone" of the brothers Rogers, of Hall and later geologists, Dr. Hitchcock presents no facts decisive of the question of its position. As to the "Georgia slate"—the "Black slate" and "Taconic slate" of Emmons—the "Hudson River group" of Hall—the "upper part of the Hudson River group, or a distinct group above the Hudson River group" on the authority of Sir William Logan—a "primordial" terrane, as determined by Barrande—Dr. Hitchcock has no decisive facts to offer. He recites the principal data touching the lithological and stratigraphic characters of the group, and acquiesces in the verdict then recently rendered by Hall and Logan in reference to the geologic age, expressly disagreeing with Emmons in regard to any unconformity between the "Georgia slates" and the "red sandrock."

The "Stockbridge limestone" of Emmons, Adams and Thompson is christened "Eolian limestone" (from Mt. Eolus, or Dorset mountain). This is the "Granular limestone" of Dewey, and "metamorphic Trenton limestone" of Rogers, Logan and Hunt. The "Sparry limestone" of Emmons is included in it. As to their geological position, Dr. Hitchcock says: "We incline to the opinion that they must probably be placed as high as that [the Corniferous] formation, or as low as the Lower Silurian, to which last position Mr. T. S. Hunt assigns them. Either position abounds with difficulties, and we are hardly prepared to choose between them," (p. 421). He has changed his view in reference to dolomitization. He says:

"The old notions that it has been done by igneous fusion, or by the sublimation of carbonate of magnesia do not all satisfy the facts as we now understand them," (p. 424). He then quotes from Bischof to the effect that dolomytes can only be regarded as a product of the alteration of limestone in the wet way (p. 424).

The "Magnesian slate" of Dr. Emmons, and of Adams and Thompson, is described by Dr. Hitchcock under "Talcoid schists," because analysis shows that they are essentially aluminous (p. 425). He regards them as probably newer than the Eolian limestone (p. 433).

The theory of the metamorphic origin of granites gains strength in the mind of the author, and he returns to it with new thoughts and new supports. He points out the improbable assumptions of the theory of molten granitic protrusions, save in an exceptional way, (ii. pp. 572, 573), and enforces the arguments for aqueo-igneous fusion of pre-existing rocks as the most probable origin of granites (ii., 574-6). He maintains, 1. The accepted theory of igneo-aqueous softening for recognized schistose rocks needs only an extension in the same direction, to apply to granitic rocks. 2. The order of solidification of the constituents of granite has not been that which would have been followed in a case of cooling from a state of fusion. 3. The existence of hydrated simple minerals. or of such as must have been formed in the wet way, or of such as would undergo partial or entire decomposition, even at a red heat, is an evidence favoring the igneo-aqueous theory. 4. The character of thin tortuous granitic veins, instead of evincing molten fluidity, seems more probably to have resulted from a state of solution or softening in alkaline thermal waters.

Dr. Hitchcock never made an explicit record of his views in reference to the tenability of the Taconic system as a whole. He opposed the earlier views of Emmons in reference to a non-inversion of the strata in western Massachusetts—though at one time wavering on that subject—and is commonly ranked with the brothers Rogers as an opponent of Emmons' claims. But Hitchcock's conception of the assumed overturn was different from that of the brothers Rogers; and Emmons yielded at last, to the evidence of a *folded* overturn. In reference to the position of the "red sandrock" at Highgate and elsewhere, Hitchcock in the earlier portion of his Vermont report, deferred to the positive opinion of W. B. Rogers*, and in this respect was again at variance with Emmons, who held it to lie in the position of the Potsdam sandstone and the Calciferous sandrock†. As to the Georgia slates, which the majority of American geologists had pronounced equivalents of the Hudson River series, or newer, Dr. Hitchcock appears finally to waver. He quotes the changed opinions of Logan, and the positive assertions of Barrande, as well as Hall's explanations of his positions, and as to himself, confesses that he no longer takes sides—though apparently he admits, with Logan, that the Point Lévis rocks are subordinate to the Potsdam, instead of near the middle Silurian. But on still later pages‡, he compiles a resume of the Taconic system, saying, "We shall use the terms which are employed by Prof. Emmons, and shall endeavor to represent his ideas *as they are published*, as faithfully as though we were the amanuensis of an advocate of the Taconic system." This epitome, therefore, is not compiled in a controversial spirit. Moreover, it soon becomes manifest that some of the reasoning is Dr. Hitchcock's own; that is, he assumes the character of a friend and advocate. He concludes with a statement of "presumptions in favor of the Taconic system": "1. Its similarity to the Cambrian system in Europe." From this is deduced, "2. A presumption that the old doctrine of the Laurentian age of the New England azoic rocks is correct." "3. The Taconic rocks are physically unlike the Lower Silurian." "4, The Taconic system underlies the Lower Silurian." "5. The thicknesses of the Taconic and Lower Silurian rocks do not agree." "6. The organic remains of the Taconic and Lower Silurian rocks are entirely different from one another."

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* [illegible]

† [illegible]

‡ [illegible]

HENRY D. ROGERS.

1842. In their classic memoir "On the Physical Structure of the Appalachian Chain,"[*] the brothers Rogers say:

"At an early period in the geological surveys of New Jersey and Virginia, we were struck with the great prevalence of the southeasternly dip of the strata, throughout the portions of the Appalachian chain traversing those states, and recognized its dependence on the oblique or inverted folding of the strata. This will appear from the descriptions we have given in our Annual Reports for 1837 to 1839. The important general law of the greater steepness of the dip on the northwestern than on the southeastern sides of the anticlinal axes, became known to us at the same stage of our inquiries and was first announced in the Final Report on the geology of New Jersey, written in 1839, and published early in the spring of 1840" (p. 481).

Another anouncement of these views was made to the American Philosophical Society in January, 1841.[†]

After adverting to the statements of previous writers that all the strata between the Hoosac mountain [Massachusetts] and the Hudson river lie in an inverted order, drawings were exhibited, proving the existence of numerous closely folded anticlinal and synclinal axes; and the inference was drawn that the inverted dip of the rocks is a result of a folding of the beds at short intervals, and not of one general turning over of the whole series, as suggested by professor Hitchcock. Subterranean igneous action was referred to as having caused this compression and folding of the rocks, and its energy was shown to have been greatest along the

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[*] *Transactions of the Association of American Geologists and Naturalists*, 1840, 1841 and 1842 pp. 474-531.

[†] *Proc. Amer. Phil. Soc.*, Jan. 1. 1841.

Berkshire valley, and the ridges lying to the east. To the same agency was attributed the crystalline condition of the Berkshire marble and of the associated schists and semi-vitrified quartz rock · the first being regarded as merely the blue limestone of the Hudson valley, extensively altered, and the last, a highly altered form of the white sandstone at the base of the Appalachian formations (p. 482).

Speaking of the character of the flexures in the Hudson River division, they say:

"In this belt the flexures are, for the most part, of the closely folded type, and the dip is almost invariably toward the southeast, the compressed and oblique plication of the beds extending equally to the hypogene or primary rocks of the mountains bounding the valley in the east, and to the lower formations of the Appalachian system which occupy the valley itself" (p. 486).

"A feature of frequent occurrence in certain portions of the Appalachian belt, is the passage of an inverted flexure into a fault" (p. 494). "It is an interesting general fact that the space between the axes, or, more properly, the amplitude of the undulations, increases as we cross the chain northwestward" (p. 507).

1844. These views have a bearing on the interpretation of the structure occurring on the east of the Hudson river, within the geographical limits of the Taconic system. In the light of them, professor H. D. Rogers used the following language in reference to the proposal of Emmons.[*]

"The fixing of a base for the Palæozoic rocks of the United States is a problem scarcely less difficult than that of determining the lower limit of the corresponding system of England, to which the admirable sagacity of Sedgwick has been so usefully directed. Do we possess, in the so-called Taconic system of rocks lying to the southeast of the unequivocally fossiliferous strata at the base of the New York or Appalachian system, an independent mass of formations of an unquestionably earlier date, or are these, on the other hand, but well known lower Appalachian strata disguised by some change of mineral type and by igneous metamorphosis? These Taconic rocks, under the form they assume along the eastern boundary of New York and the western side of Vermont and Massachusetts, have been carefully studied by Emmons, Hitchcock and Mather; all of whom appear to have arrived at different conclusions concerning them.[†] . . . Professor Emmons considers the granular quartz, slate and limestone of the Taconic hills and the Stockbridge valley as constituting a distinct group of strata. . . . His principal argument in defense of this view is, that the order of succession of the component members of the group is essentially different from that witnessed in the sandstone, limestone and slate of the Champlain division, and he denies that the theory of plication of the beds, advanced originally by myself and my brother, and applied to this very region, can reconcile the seeming want of agreement. Now it is true that the apparent order of superposition in the Taconic belt is in discrepancy with the well known succession of the Champlain formations, but this is precisely what should arise from the introduction of those complete folds or doublings together of the strata which we have conceived to exist; and I would add that the sections furnished by professor Emmons and professor Mather in their reports, if resolved by the introduction of the flexures supposed by us, will all of them display, for their western portions at least, the normal order of superposition of the Champlain rocks. This identity of the so-named Taconic System with the formations of the Hudson and Champlain valley was announced by my brother and myself, in the beginning of 1841, to the American Philosophical Society. By the aid of a section from Stockbridge towards the Hudson river, we showed the existence of numerous close anticlinal folds, and thus explained the apparent inversion of the dip, which other geologists had ascribed to one general overturning of the whole series. The plication was shown to be greater along the Berkshire valley and the ridges west; the granular Berkshire marble was identified with the blue limestone of the Hudson valley, but metamorphosed by heat, and the associate micaceous, talcose and other schists were referred, in the language of the communication, to the slates of the formation of the Appalachian system; while the

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[*] *Amer. Jour. Sci.*, XLVII, 150, Oct., 1844.

[†] Professor Mather's conclusions are embodied in the preface to the report on the *Geology of the First District of New York*, 1843, p. viii. Referring to the views of the pro-

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fessors Rogers, he says: "I concur with them in this opinion. My own observations on these rocks (from the Hoosac mountain to the Hudson) and those of the Hudson valley, conducted with much care throughout their whole extent, in New York, and in Vermont and Massachusetts, through a series of years, have led me to the conclusion that they are metamorphic, and of the age of the Champlain division; that they are the altered limestones, slates and sandstones of that division . . . The white limestone containing plumbago and various crystallized minerals is another point on which there are various views. I have come to the conclusion that it is metamorphic, but in more highly metamorphic state than the dolomitic limestones of the Taconic rocks."

Chapter vii., however (pp. 422-438), is devoted to the "Taconic System". But, at the end, professor Mather remarks: "It will be observed by those who have read the preceding details in regard to the Champlain Division and the Taconic System, that they are considered to be the same rocks, the latter somewhat modified in character by metamorphic agency" (p. 438).

In the chapter on Metamorphic Rocks, he says: "In describing the Taconic rocks separately, I have yielded to the opinion of some of my colleagues who have considered them as interposed between the Champlain Division and the Primary. I can discover no evidence of any such interposition . . . " (p. 446).

semi-vitreous quartz rock of the western part of the Hoosac mountains was stated to be nothing else than the white sandstone (Potsdam sandstone) of the same series slightly altered. . . . It is true Professor Emmons has presented in his report, a series of sections of the strata exhibiting an unconformity at the passage of his Taconic into the rocks of the Champlain division, but I must take the liberty of expressing my disbelief of the existence of any such unconformity, and of observing that, in the prolongation southwestward of this altered and plicated belt, as far as the termination of the Blue Ridge in Georgia, a distance of one thousand miles, no interruption of the general conformity of the strata has ever met the observation of my brother or myself."

"It would appear thus, that the Potsdam sandstone forms the base of the Palæozoic strata in the latitude of lake Champlain, or at least in the region of the lake and the Mohawk river" (pp. 151-152).

Professor Rogers adds some suggestions which in the light of later palæontological developments, must be regarded prophetic.

"Is this formation, then, the lowest limit of our Appalachian Palæozoic masses generally, or is the system expanded downwards in other districts by the introduction beneath, of other conformable sedimentary rocks? From the Susquehannah river southwestward, a much more complex series of strata comes in below the bottom of the lowest limestone, than is anywhere seen northeast of the Schuylkill. In some portions of the Blue Ridge belt there are at least four independent, and often very thick deposits constituting one general group, in which the Potsdam, a white sandstone. is the second in descending order. The uppermost of these is an arenaceous and ferriferous slate, many hundred feet thick, in which the only fossil is a peculiar fucoid. Beneath this lies the Potsdam sandstone, and under this again, a mass of coarse sandy slate and flaggy sandstone, amounting sometimes to six or seven hundred feet, below which occurs in Virginia and East Tennessee,* a series of heterogeneous conglomerates. Neither of the two lowest of these masses has yet rewarded research with a single fossil" (p. 152).

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* Professor Safford in his admirable digest of the "*Geology of Tennessee*" (pp. 151, 152, 182) described the Potsdam group as composed of: 2c. The Knox Group of Shales Dolomites and Limestones; 2b. The Chilhowee Sandstone (Potsdam proper); 2a. The Ocoee Conglomerate and Slates (Eozoic). Below these are the metamorphic rocks gneiss, mica slate, syenite and chloritic slates. Dr. Safford says: "The metamorphic beds together with those of other groups that are adjacent or neighboring, all appear to follow the same law of dip and strike. The dip is, in the main, at a high angle to the southeast. . . . They all apparently belong to the same system of upheavals. . . . With reference to age, I have no reason for believing that the group within Tennessee includes the metamorphosed beds of any formation of more recent date than the Ocoee conglomerate and shales" (p. 177).

"Adjoining this great mass of arenaceous strata toward the southeast we find throughout much of the broad belt of the Blue Ridge, especially in its prolongation southwestward from the Potomac, a wide expansion of metamorphic strata intersected by innumerable veins and dykes of greenstone and other igneous materials, and displaying almost every grade and variety of alternation in texture and mineral contents. These, after long and careful observation, we have been led to consider as a group of sedimentary beds, still older than the preceding, but forming a part of one and the same unbroken series. Thus, then, in the great group of strata at the base of our lowest fossiliferous series, we are presented with similar and perhaps more striking results of igneous modifying powers than even in that portion of the Champlain system whose metamorphosed rocks constitute the Taconic group. . . . Respecting the phenomena presented in the long belt of rocks here referred to, the question suggests itself whether the so-called Taconic system instead of belonging exclusively to the Champlain division, may not, along with the western border of Vermont and Massachusetts, include also, some of the sandy and slaty strata here spoken of as lying beneath the Potsdam sandstone" (p. 153).

In his final Report on the geology of Pennsylvania, published in 1868,* professor Rogers, in speaking of the Second or Middle Belt of Gneiss, in the southern gneissic district, says: "It would seem as if these minerals had crystallized or segregated from their parent sedimentary materials, under a conflict of forces, the newly awakened crystallizing energies being not always parallel to the original bedding of the deposit, but more frequently oblique to it" (p. 71). This remark is made in view of the "wavy or minutely undulated lamination, arising apparently, from a contorted or wavy structure in the coarsely crystallized mica, its predominant mineral, which he thought, seemed "to proceed from the interference of innumerable planes of cleavage - or what is the same thing —of crystalline lamination, with the original planes of deposition of the strata."

He remarks a character which possibly might be attributed to remoteness of the upper gneisses from the zone of intense crystalline action:

**The Geology of Pennsylvania, Government Survey.* By Henry Darwin Rogers. In two vols. 4to, New York, 1868. The author informs us in the preface that the survey was commenced in 1836; interrupted from failure of appropriations in 1842; revived in 1851 (after sundry failures in attempts to accomplish publication); the field work was concluded in 1855, report rewritten and placed in way of publication under direction of the author. The preface is dated Philadelphia, April, 1858.

"A remarkable feature in the northern or uppermost band of gneiss on the Schuylkill, or those which next adjoin the base of the Primal series, is the possession of a less than usual completeness of crystallization in the constituent minerals, the feldspar more especially, appearing to be less perfectly developed than common, and more in the condition of roundish or lenticular, segregated lumps. In this circumstance, the gneiss here approximates somewhat to the structure of the lowest beds of the Primal series, which are also porphyroidal, but exhibit their metamorphism in a far lower degree" (p. 73).

The prevailing Appalachian dip is not remarked in the gneisses:

"A remarkable feature in the structure of the whole southern gneiss district is the prevalence of a northward dip in the strata. This inclination prevails along the Schuylkill, with very few local and trivial exceptions throughout all the three great subdivisions of the zone of gneiss" (p. 78).

I make one more quotation, setting forth a conception in reference to Appalachian structure, which demonstrates long and thoughtful observation:

"That the wide area of gneiss now under description is undulated in a succession of anticlinal and synclinal waves is obvious to any practiced geological observer who studies its structure with due care. . . The notion of an undulated or folded structure in the gneiss finds corroboration in the parallel arrangement of the hills and valleys; and in the sudden changes in the dip of the strata, wherever we make a transverse section through the region; but it receives its most positive demonstration, when we study the topography and distribution of the gneiss on the western side of the county. There as we have already seen, several long tapering tongues of the gneiss formation project forward towards the W, including between them actual troughs of the Palæozoic rocks, a feature not attributable to any other mode of elevation of the gneiss than that of an undulation of its general floor in the manner of long anticlinal waves" (p. 86). In reference to inverted flexures in the South mountains, see page 94.

JAMES HALL.

1843. In his Final Report on the geology of the Fourth District of New York,* Mr. Hall, like Mr. Mather and Mr. Vanuxem,** makes mention of the Taconic system, then recently proposed by Dr. Emmons. But, with Mr. Hall, a mere mention suffices. He says: "II. Taconic System. Represented by the Taconic range of mountains in the eastern part of New York." (p. 17.)

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*Geology of New York. Part IV. Comprising the Survey of the Fourth Geological District. By James Hall. Albany, 1843.

**Vanuxem's chapter on the Taconic system occupies but about one page (pp. 22,23.) The rocks of the system barely entered his district. Unlike Mather, he agreed with Emmons as to the validity of its existence. The following, however, is a curious paragraph:

1847. Mr. Hall's attitude toward the Taconic was disclosed in the first volume of the Palæontology of New York* where the trilobites described by Dr. Emmons under the names *Atops trilineatus*, and *Elliptocephalus asaphoides*, as representatives of Taconic life, were described as *Calymene beckii*, an authentic species of the Hudson River group, and *Olenus asaphoides*, presumed also to be of similar age. He says:

"Supposing the existence of a system of strata below the Potsdam sandstone, of which we have no proof, we might fairly infer that the wide interval between the deposition of those strata and the Hudson River group, would give us forms of animal life more widely different than these examples offer" (p. 257, note.)

1859. So far as I have observed, professor Hall had no occasion to assume positions bearing on any questions concerning pre-Silurian rocks, until some [assumed] "Trilobites of the Shales of the Hudson River Group" from northern Vermont, were placed in his hands.† These were described as *Olenus thompsoni*, *Olenus vermontana and Peltura (Olenus) holopyga* (pp. 59-62). These fossils, as it appeared, were obtained from the district claimed by Emmons as representing the Taconic system. Though these were not generic types characteristic of the horizon of the Hudson River group, the controlling reason for placing them there, is expressed in the appended note as follows:

"NOTE. In addition to the evidence heretofore possessed regarding the position of the slates containing the trilobites, I have the testimony of Sir W. E. Logan, that the shales of this locality are in the upper part of the Hudson River group, or forming a part of a series of strata which he is inclined to rank as a distinct group, above the Hudson River proper. It would be quite superfluous for me to add one word in support of the opinion of the most able

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"It is a convenient receptacle for deposits which belong neither to the Primary nor the New York System: and the mind in England is disposed to one of the kind, since the Cambrian System holds the same position. From [To] the necessity of a connecting link between the Primary and the Secondary classes, which alone existed when Werner rose as a geologist, we owe the Transition class, the fruits of which are the Cambrian System of Mr. Sedgwick, the Silurian of Mr. Murchison, and the Devonian of Mr. Phillips: now merged, with the exception, probably, of a portion of the Cambrian, in the New York System.'

**Palæontology of New York*, Volume I. By James Hall, 1847.

†*Twelfth Annual Report of the N. Y. Regents. Contribution to the Palæontology of N. Y., 1855, '56, '57 and '58.* By James Hall. 1859. Professor Hall has informed us that this report was published previous to Sept. 20, 1859.

stratigraphical geologist of the American continent" (p. 62, note.)

1860. In the Thirteenth Report of the Regents*, professor Hall changed the generic references of the three trilobites just mentioned, establishing for them, two new genera. They are here described (the first with a new figure) under the names *Barrandia thompsoni*, *Barrandia vermontana* and *Bathynotus holopyga*. The technical reasons for these changes are explained. In reference to geological position, he says, in a paragraph at the end:

"The geological horizon of the shales in which these trilobites occur, having been made a matter of discussion among geologists, I shall refer those interested in the subject to the forthcoming report upon the Geology of the State of Vermont, by Professor E. Hitchcock," (p. 119, see anté, p. 99).

1861. This reference of the Georgia trilobites a horizon as high as the Hudson River group, was questioned and somewhat sharply criticised by M. Barrande† in 1860. Professor Hall, accordingly, made a restatement of the reasons which induced him to refer the Georgia trilobites to the Hudson River horizon. The truth of history, not to say justice to professor Hall, demands the quotation of some passages.‡ After stating that Sir William Logan had authorized in an explicit manner, the note appended to his paper in the *XIIth Regents' Report*, he proceeds:

"Later discoveries in the limestones associated with the shales at Quebec leave no longer a doubt, if any could have been entertained before, that the shales of Georgia, Vermont, are in the same relative position [i. e., of Quebec age, instead of Hudson River] and we must regard these three trilobites as belonging to the same fauna with the species enumerated by Sir William Logan as occurring in the Quebec group. Left to palæontological evidence alone, there never could have been a question of the relations of

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**Appendix. Contributions to Palæontology, 1858 and 1859, with additions in 1860.* By James Hall. This report, according to a slip attached to *XIVth Report*, was published before Dec. 17, 1860.

†*Neues Jahrbuch für Geologie und Petrefaktenkunde.* A translation of the letter written under date of Paris, July, 16, 1860 to Prof. Bronn is given by M. Marcou, in a memoir entitled "On the Primordial Fauna and the Taconic System. By Joachim Barrande. With additional notes." From the *Proceedings of the Boston Society of Natural History*, vol. vii., Dec., 1860, pp. 359-382. Republished in *Amer. Jour. Sci.*, II., xxxi, pp. 212-15, Mar., 1861. M. Barrande wrote of these fossils: "Their primordial nature cannot admit of the least doubt, when the descriptions are read, accompanied with wood engravings which the large dimensions of these three species render sufficiently exact......All the characters of these three trilobites, as they are recognized and described by J. Hall, are those of the trilobites of the Primordial fauna of Europe. . Such is my profound conviction, and I think any one who has made a serious study of the trilobitic forms, and of their vertical distribution in the oldest formations will be of the same opinion" (pp. 371-372.)

‡*Amer. Jour. Sci.*, II, xxxi, pp. 220-6, March, 1861; *Canad. Naturalist*, vi, 113-20, Apr. 15, 1861; Geol. Vermont, i, 382-6.

these trilobites, which would at once have been referred to the Primordial types of Barrande.

"Sir William Logan yields to the palæontological evidence, and says, 'there must be a break.' He gives up the evidence of structural sequence which he had before investigated, and considered conclusive; and having heretofore [myself], relied upon the opinion of the distinguished geologist of Canada, in regard to a region of country to which my own examinations had not extended, I have nothing left me but to go back to the position sustained by the palæontological evidence." *

He then examines the palæontological evidence, and from a tabular exhibit of Quebec fossils, concludes:

"In the table we find, of previously recognized tribolites of the primordial faunæ, four genera and eight species; two genera before known in the Potsdam sandstone, and seven species; and of *Agnostus*, which is of the first and second faunæ, two species; and one new genus, with nine species."

"These are certainly very curious results; and a modification of our views is still required, to allow four genera and eight species, or, leaving out *Amphion*, three genera and six species of tribolites of the second fauna, to be associated with two genera and five species of tribolites of the primordial fauna, and yet regard the rocks as of primordial origin" (pp. 224). . . .

"In the present discussion, it appears to me necessary to go further, and to inquire in what manner we have obtained our ideas of a primordial or of *any* successive faunæ. I hold that in the study of the fossils themselves, there were no means of such determination prior to the knowledge of the stratigraphical relations of the rocks in which the remains were enclosed. There can be no scientific or systematic palæontology without a stratigraphical basis. Wisely then, and independently of theories, or of observations and conclusions elsewhere, geologists in this country had gone on with their investigations of structural geology. The grand system of Professors W. B. and H. D. Rogers had been wrought out, not only for Pennsylvania and Virginia, but for the whole Appalachian chain, and the results were shown in numerous carefully worked sections. In 1843, '44 and '45, I had myself, several times crossed from the Hudson river to the Green mountains, and found little of importance to conflict with the views expressed by the Professors Rogers in regard to the chain farther south, except in reference to the sandstone of Burlington, and one or two other points, which I then regarded as of minor importance."

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* *Amer. Jour. Sci.*, II. xxxi. 221.

"Sir William Logan had been working in the investigation of the geology of Canada; and better work in physical geology has never been done in any country."

"This, then, was the condition of American geology, and investigators concurred, with little exception, in the sequence based on physical investigations. As I have before said, our earliest determinations of the successive faunæ depend upon the previous stratigraphic determinations. This, I think, is acknowledged by Mr. Barrande himself, when he presents to us as a preliminary work, a section across the centre of Bohemia. With all willingness to accept Mr. Barrande's determination, fortified and sustained as it is, by the exhibition of his magnificent work upon the trilobites of these strata, we had not yet, the means of parallelizing our own formations with those of Bohemia by the fauna there shown. . . . It then became a question for palæontologists to decide whether determinations founded on a physical section, in a disturbed and difficult region of comparatively small extent [i. e. Sir W. E. Logan's on the borders of Canada and Vermont] were to be regarded as paramount to determinations founded on examinations, like those of the Professors Rogers, extending over a distance in the line of strike of five or six hundred miles; and those of Sir William Logan over nearly as great an extent, from Vermont to Gaspe." . . .

"It is evident that there is an important and perplexing question to be determined. . . For myself, I can say that no previously expressed opinion, nor any 'artificial combinations of stratigraphy previously adopted, by me, shall prevent me from meeting the question fairly and frankly" (pp. 224-5-6).

1862. The new evidences in reference to the age of many of the rocks in the valley of the Hudson, led professor Hall to an abandonment, at least for a time, of the use of the term Hudson River group, for the assemblage of strata next above the Trenton group. In a note at the end of his report on the geology of Wisconsin, he records this changed position.*

"At that time [when the final reports on the geology of New York were in preparation] and at a later period, Dr. Emmons proposed the name Taconic System for a series of rocks lying a considerable distance to the eastward of the Hudson River, and which were, according to the author of that System, below the Potsdam sandstone. An examination of the slaty rocks of the System in some of their typical localities, proved, in the opinion of the writer, that

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**Report on the Geological Survey of the State of Wisconsin*, vol. 1. Jan. 1862. pp. 47 and 443-5.

they rested upon the Potsdam sandstone; and in tracing the same beds toward the Hudson River, there could be discovered no break or interruption in the strata anywhere to the east of that river. . . At a subsequent period, Dr. Emmons extended the application of the term Taconic System to the rocks of the Hudson River valley, including the area originally regarded as the typical locality of the Hudson River Group. . . Within the last few years, the discussion of the subject has been revived, more particularly from discoveries of fossils in Vermont and Canada, which prove conclusively that these slates are to a great extent, of older date than the Trenton limestone."

"Looking critically at the localities in the Hudson valley which yield the fossils [belonging to the second fauna] we find them of limited, and almost insignificant extent. . . Besides the fossils just mentioned, we know of no others for nearly a hundred miles along the Hudson valley, with the exception of the Graptolites, which have heretofore been referred to the age of the other fossils found in the smaller outliers, or to the second fauna, but which in reality, hold a lower position, and belong to the great mass of the shales below."

"Until recently but one or two other species of known older types of fossils (those of the Primordial fauna) had been discovered in these slates. But within the past few years, the number discovered has been very great. . . We are therefore satisfied. . . that the term Hudson River group cannot properly be extended to . . . the Lorrain shales and the shales and sandstones of Pulaski, etc. . . I have therefore dropped the term Hudson River group in its application to the rocks of Wisconsin which are of the age of the Lorrain shales of New York, and the 'blue limestone' of Ohio." . .

1864. The field examination made in 1864 in company with Sir W. E. Logan, has already been mentioned. *Ante'*, p. — This resulted in the recognition of a wide distribution southward, of rocks belonging to the Quebec and Sillery formations. These identifications were made in the midst of a region which had generally been regarded as underlaid originally by altered strata of Hudson River age.

1877. The conclusions reached in 1861 and 1862, in reference to the age of the mass of rocks along the east side of the Hudson river, were found to be only partially true.* Later investigation showed the existence along both sides of the river, of a body of

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*"Note upon the History and Value of the term Hudson River group, in American Geological nomenclature." *Proc. Amer. Assoc.*, Nashville, 1877, pp. 258-65.

slates lying in unquestionable continuity with the Lorrain shales of the Mohawk valley and the northwestern part of the state, and professor Hall therefore reclaimed the term Hudson River group as appropriate. No particular citations of reasons assigned is needed here. Professor Hall however, still recognized the existence of a mass of slates farther east in New York, which contained fossils of the Primordial fauna. These, therefore, still remained, to validate, as far as they could, Dr. Emmons' contention for the existence of a pre-Silurian, fossiliferous system.

SIR WILLIAM LOGAN.

1845. The first record of observations made by Sir William Logan on the range of rocks here under consideration*, speaks of them collectively, as the "Metamorphic Series." But he recognizes a lithological and chronological subdivision.

"To the south of the Mattawa and of the Ottawa in its continuation after the junction of the two streams, important beds of crystalline limestone become interstratified with the syenitic gneiss,and their presence constitutes so marked a character that it appears expedient to consider the mass to which they belong as a separate group of metamorphic strata, supposed, from their geographical position and general attitude, to overlie the previous rock conformably. The limestone beds appear to be fewer at the bottom than at the top of the group, but whether few or many, they are always separated by beds of gneiss which in no way differ in constituent quality or diversity of arrangement from the gneiss lower down, except in regard to the presence of accidental minerals, the most common of which are garnets," (pp. 41, 42).

The facts stated would seem to afford but slender ground for the recognition of two "groups."

But this grouping is traced over an extent of sixty-three miles, when the result of his observations is expressed in the following arrangement:

4. Fossiliferous limestone [with Niagara fossils.]
. Greenish sandstones [of undetermined relations.]
2. Chloritic slates and conglomerates [subsequently Huronian.]
1. Gneiss (p. 67.)

1846. The series on the north shore of lake Superior is further described in the report of the following year†. The order of succession determined is given below:

5. Sandstones, limestones, indurated marls and conglomerates, interstratified with trap.

**Report of Progress of the Canada Geological Survey for 1845-6*, pp. 40-45.
†*Report of progress for 1846-7*, pp. 8-17.

4. Bluish slates or shales, interstratified with trap. [Huronian Animike.)
3. Chloritic and partially talcose and conglomerate slates.
2. Gneiss.
1. Granite and syenite.

On these Mr. Logan makes the following remarks:

"The rock at the base of the series is a granite, frequently passing into a syenite by the addition of hornblende; but the hornblende does not appear to be often present wholly without the mica. . . This granite appears to pass gradually into a gneiss, which seems to participate as often in a syenitic as a granitic quality. . . The gneiss is succeeded by [3] slates of a general exterior dark green color, often dark gray in fresh fractures, which at the base appear occasionally to be *interstratified* with beds of a feldspathic quality, of the reddish color belonging to the subjacent granite and gneiss. . . Some of the beds have the quality of a greenstone, others, that of a mica slate, and a few present the character of quartz rock. Rising in the series, these become [4] interstratified with beds of a slaty character, holding a sufficient number of pebbles of various kinds to constitute conglomerates. The pebbles seem to be of various qualities, but apparently all derived from hypogene rocks. . . [Ogishke conglomerate?] "The formations which succeed [5] rest *unconformably* upon those already mentioned. The base of the lower one where seen [in Thunder Bay] in contact with the subjacent green slates presents conglomerate beds, probably of no great thickness, composed of quartz pebbles chiefly, with a few of red jasper, and some of slate in a green arenaceous matrix, consisting of the same materials in a finer condition." [Afterward "slate conglomerate."]

The [5] sandstones, limestones, indurated marls and conglomerates, are said to be crowned by an enormous amount of volcanic overflow.

In the light of our own studies, it becomes easy to recognize in No 3 the rocks of the Keewatin iron-bearing series, represented on the south shore by the Marquette iron-bearing series; in No. 4, the chloritic diabase slates of the Thessalon valley, and in No. 5, the "slate conglomerate" and quartzites and Trap-rocks of the same regions, and the Animike slates of northeastern Minnesota,* while the crowning overflow is the great gabbro sheet so widely spread in northern Minnesota.

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*Erroneously supposed by Whitney and Wadsworth to represent the Cupriferous formation of the south shore (*Azoic Rocks*, p. 334). As the Cupriferous is with them of Potsdam age, we should have an astonishing equivalency between the Potsdam sandstone and the Animike black slates.

It is important to keep in mind the early recognition of an unconformity between the two series of schists Nos. 3 and 4, and the existence of quartzose pebbles in the bluish slates,[*] as in the blackish slates of the Thessalon valley.

1847. In order to describe the grounds of director Logan's determinations respecting the geology of the region north of lake Huron it is necessary to make a quotation from Mr. Murray's report of a survey in 1847.[†]

"The older groups observed, consist firstly, of a metamorphic series composed of granitic and syenitic rocks in the forms of gneiss, mica slate and hornblende slate; and secondly, of a stratified series, composed of quartz rock or sandstones, conglomerates, shales and limestones. . . . On a cluster of small islands, . . . granite was found breaking through the quartz rock. The color of the rock [which rock ?] was red. On one of the islands, quartz rock beds on opposite sides of the granite, were observed to dip in opposite directions, north on the north side, and south on the south side, at an angle of 78° or 80° ; and in another of the islands, the quartz rock and granite were seen in juxtaposition, the former reclining on the latter. In this case the quartz was traversed by several trap dikes running slightly oblique to the strike, while granitic veins ran transversely through the whole, and were continued through the main body or nucleus of the granite, the one granite being distinguishable from the other notwithstanding the red color of both, by the finer texture of the veins" (pp. 112, 113).

This is the earliest description of a portion of the rocks in what was to become "the original Huronian region." An examination of the statements made by Mr. Murray justifies the conclusion that the rocks described correspond to the 'upper group' found by Logan on the north shore of lake Superior. But it will be seen that Logan parallelizes them with the *metamorphic* series of the north shore, without paying due regard to the unconformity which he has described running between the upper and lower groups. Thus, in reference to the second series of Mr. Murray, he writes in 1848 : *

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[*] These are described as *black* argillaceous slates by Mr. Alexander Murray (same report, pp. 51-3). After noticing the two groups and the structurally *conformable* passage of the lower into the bottom gneisses, he says of the upper (black argillaceous slates): "The base of this formation . . . . was observed on the Kaministiquia, near the Grand Falls. Its immediate junction with the rock on which it reposes was concealed from view, but appears to be indicated by the position of a small lake or pond occurring just below the second portage, and the marshy ravines which run from it in the direction of the strike on each side. The slates visibly reach to within a short distance of the pond, probably brought into place against the syenite by a dislocation.

[†] Murray, *Report of Progress for 1847-8.*

"The series of rocks occupying this country form the connecting link between lakes Huron and Superior to the vicinity of Shebawenahning, a distance of 120 miles, with a breadth in some places of ten, and in others exceeding twenty miles, and it appears to me, must be taken as belonging to one formation; on the west it seems to repose on the granite which was represented in my report on lake Superior as running to east of Gros Cap, north of Sault Ste. Marie ; on the east, the same supporting granite was observed by Mr. Murray, north of La Cloche, between three and four miles in a straight line up the Rivière au Sable, . . . and again about an equal distance up another and parallel tributary, . . . in both cases, about ten miles from the coast. . . . In respect to the geological age of the formation, the evidence afforded by the facts collected last year by Mr. Murray, . . . is clear, satisfactory, and indisputably conclusive. . . . The chief difference in the copper-bearing rocks of lakes Huron and Superior seems to lie in the great amount of amygdaloidal trap present among the latter, and of white quartz rock or sandstone among the former. But on the Canadian side of lake Superior, there are some considerable areas, in which important masses of interstratified greenstone exist without amygdaloid, [this is the 'upper group'] while white sandstones are present in others, as on the south side of Thunder Bay, though not in the same state of vitrification as those of Huron. But notwithstanding these differences, there are such strong points of resemblance in the interstratification of igneous rocks, and the general mineralized condition of the whole, as to render their positive approximate equivalence highly probable, if not absolutely certain ; and the conclusive evidence given of the age of the Huron, would thus appear to settle that of the lake Superior rocks, in the position given to them by Dr. Houghton, the late state geologist of Michigan, as beneath the lowest known fossiliferous deposits, a position which, as will be seen by a reference to the Report of Progress I had the honor to submit to your Excellency, in 1846, appeared to me to derive some support from evidences on the Canadian side of lake Superior itself."

The positive error embodied in the foregoing paragraph is the attempt to parallelize the Huron rocks with a series of Superior rocks which consists of two groups, and then having shown the parellelism with the higher group, the drawing of inferences touching a

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* *Report on the north shore of Lake Huron*, Dec. 29, 1848, pp. 8, 9, 19, 20.

third geological region which are valid only in reference to the lower Superior group.

The foregoing citation from the report of 1848, was embodied in a communication made by director Logan to the British Association in 1851.* But in place of the last part of the last sentence, we find the following: "and in this sequence, those [rocks] of Lake Huron, if not those of Superior, would appear to be contemporaneous with the Cambrian series of the British Isles." In the next paragraph, he says the Lower Silurian, on the lower St. Lawrence, "appears to rest upon gneissoid rocks, without the intervention of the Cambrian" (*Amer. Jour. Sci.*, l. c., p. 226;) and in the next, he uses the phrase, "Cambrian formation of Lakes Huron and Superior" (p. 227), and the same again on the next page. It is clear then, that in 1851, Sir William Logan considered the rocks on the north shore of lake Huron as equivalent to the Cambrian of Sedgwick.

1848. We must again cite from Murray, as it appears that director Logan's judgments were largely based on assistant Murray's facts. In the report for 1848–9, after describing the country along the Spanish river, he says:

"The geological formations met with in the region thus described, may be arranged in two groups, one of which appears to be nearly allied to, and the other identical with, the older rocks of which mention was made in my report of 1847–8. They are

2. Quartz rock group.
1. Granitic or Metamorphic group.

Mr. Murray, in describing the lower group, mentions only granitoid rocks. He says: "The constituent minerals were usually those of granite or syenite, or a mixture of both. . . A gneissoid structure was observed on one or two occasions, . . but obscure and ill defined." Speaking of the "Quartz rock group," he says: "The rocks of this group, where they came under our observation, like those examined the previous season, were found to be partly of aqueous and partly of igneous origin." After describing the quartzose members, he speaks of the slate. "The slates were gray, green or blackish in color, and were usually more or less silicious, and frequently very micaceous. . . The more purely argillaceous portions of the slate were generally *black* or of a *very dark brownish* tinge, and in these a very symmetrical jointed structure, dividing the rock into rhombohedral forms of considerable regularity, was frequently recognized. The slates were very

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**Rep. Brit. Assoc. Adv. Sci.* 1851. Trans. Secs. 59-62 *Amer. Jour. Sci.* II, xiv, 224-229. See also *Bull. Soc. géol. de France*, 1849-50, (2). vii, 207-209.

often observed to pass into a conglomerate, holding pebbles of granite and syenite chiefly, varying in diameter from an eighth of an inch to a foot, and imbedded in a *black argillaceous matrix*" (p. 37.)

No one who has seen Logan's slate conglomerates in the valley of the Thessalon, can fail to recognize the identity of the argillaceous slates described by Mr. Murray.

1849. In the report for 1849–50, director Logan describes the geology about Bay St. Paul and Murray bay. He classifies the rocks as follows:

4. Bituminous limestone (Trenton.)
3. Calciferous sandrock.
2. White quartz rock (Potsdam sandstone.)
1. Metamorphic group (p. 8.)

Referring to the "Metamorphic group," he states that the prevailing rock of the country is gneiss, sometimes of a granitic and sometimes of a syenitic character. After careful local details, he says:

"The gneiss of this district belongs to that metamorphic group of rocks, which in previous reports has been described as existing on the Ottawa, and as traceable thence . . to Cape Tourmente below Quebec. . . None of the highly crystalline limestones which on the Ottawa are so marked a feature of the group, were observed in the region under attention."

This fact gives support to the suggestion of Whitney and Wadsworth that the Laurentian limestones may be mere segregations, instead of extensive strata.

A white, translucent, slaty quartz rock, rendered cleavable by the presence of silvery mica, but seen only at three points, directly overlies the gneiss. "There appears to be little doubt that this rock is equivalent to the Potsdam sandstone of New York" (p. 10.)

1851. This year director Logan and assistant Murray examined different portions of the district between the Ottawa and the St. Lawrence. Mr. Logan describes the Potsdam sandstone as reposing unconformably on the "Metamorphic or gneissoid group" (p. 6.) The character of this "group" may be learned from Mr. Murray's description of the geology of Rigaud mountain (*Report of Progress*, p. 63.) After speaking of the occurrence of gneisses, he says:

"These beds are *interstratified* with others of a different character; one set is composed of small cleavable forms of black hornblende and grains of translucent, yellowish-white feldspar, weathering opaque-white, and crystals of brown mica. Another consists of grayish-green cleavable pyroxene, with individuals of greenish feldspar weathering white, and largely disseminated grains of magnetic iron; and a third consists of translucent albite, with black hornblende and magnetic iron ore disseminated, alternating with micaceous layers. All these beds are intersected by transverse dykes, some of which are fine-grained, grayish-black trap, probably a greenstone with disseminated grains of calc-spar, while others are porphyritic, having a fine grained blackish-green base, with individuals of greenish white feldspar" (pp. 63-64.)

This passage sounds very unlike the descriptions of the rocks about Spanish and Thessalon rivers. But these are the rocks which in the Seigniory of Rigaud, rest directly upon the gneisses. It is further stated (pp. 60, 65,) that at the base of 71 feet of sandstone, on Bluff island in Charleston lake, is a "red talco-quartzose rock of the Metamorphic series." No such rock is described in the region north of lake Huron. There is reason to suppose another group of rocks rests in this region in a position between the gneiss and the "Huron rocks."

Of the deeper gneisses Mr. Murray supplies some interesting information:

"Near Furnace Falls, on the second lot of the eighth concession of Landsdowne, there is a considerable display of crystalline limestone, holding as usual, spangles of graphite and mica, with grains of quartz. . . Crystalline limestones are also, extensively exhibited in the neighborhood of Beverly, township of Bastard, and Newboro' in south Crosby. Their color is usually white, but sometimes grayish-white, or white with gray bars or stripes. Small scales of graphite are invariably disseminated through the rock, with serpentine, mica and iron pyrites. . . The texture of the limestones is usually coarse. . . Nodular masses of vitreous white quartz, surrounded with thin layers of brown mica, and both enclosed in foliated green pyroxene, are met with in some of the beds. . . On the twenty-fourth lot of the tenth concession of Bastard, there is an unmistakable bed of *conglomerate*, interstratified between two beds of highly crystalline limestone, showing the sedimentary origin of the Metamorphic series. The following is a condensed statement of the section given (p. 62.)

7. Crystalline limestone, white, coarse-grained, 6 ft
6. Crystalline limestone, fine, very hard, bluish-gray, 4in.
5. Calcareous sandstone, fine-grained, 2 in.
4. Coarse conglomerate. The pebbles are flat and lie on their sides, etc., 1ft. 6in.
3. A calcareous aggregate of quartz, with feldspar, calc spar and scales of graphite, 2in.

2. An aggregate of colorless, translucent quartz, with feldspar and patches of greenish, chloritic limestone, with brown mica, 4in.
1. Pure white, highly crystalline, coarse limestone, 5ft.

1852. Director Logan returns to an exposition of the rocks north of lake Huron,[*] and states:

"On Lake Huron, the Lower Silurian group rests unconformably upon a silicious series, with only one known band of limestone, about 150 feet thick, with leaves of chert in abundance, but as yet, without discovered fossils. This series is supposed to be of the Cambrian epoch. It comprehends the Copper-bearing rocks of that district, and with its igneous, interstratified masses, has a thickness of at least 10,000 feet. The gneissoid group, of which mention is made, is probably still older than this. Its conditions appear to me to make it reasonable to suppose that it consists of aqueous deposits in an altered state."

1854. The first announcement of the term Laurentian, as the designation of a series of rocks, was made in 1854.[†]

"The name which has been given in previous reports to the rocks underlying the fossiliferous limestones in this part of Canada, is the "Metamorphic series;" but inasmuch as this is applicable to any series of rocks in an altered condition, and might occasion confusion, it has been considered expedient to apply to them for the future, the more distinctive appellation of the *Laurentian series*,[‡] a name founded on that given by Mr Garneau, to the chain of hills which they compose."

In the same report, Mr. Murray, writing of the region between lake Ontario and lake Simcoe, supplies a general description of the Laurentian series, in these words:

"They consist of masses of micaceous and hornblendic gneiss, and masses of crystalline limestone interstratified by gneiss. In the great masses of gneiss, the prevailing color appears to be reddish, but they are frequently striped with interstratified bands of gray, the reddish part taking its general aspect from the reddish feldspar which is the principal constituent, while the gray is chiefly made up of small grains of white quartz and feldspar, with small scales of black mica, and occasionally grains of black hornblende. . . Beds also occur of which almost the only constituent is white quartz, and these often alternate with thin layers of yellowish white feldspar," (pp. 81, 82).

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[*] *Quar. Jour. Geol. Soc.*, viii, 210, 1852.

[†] *Report of Progress, Geolog. Surv. Canada, for the year 1852-3*, Quebec, 1854, p. 8.

[‡] The term "Laurentian" had already been applied, in 1851, by Edward Desor, to the fossiliferous marine Drift of the valley of the St. Lawrence river (*Proc. Boston Soc. Nat. Hist.*, Feb. 19 and March 5, 1851, vol. IV, pp. 20, 33.) It was also published in the *Bulletin of the Geological Society of France* in the same year and in 1852; in the Neues Jahrbuch for 1853; and in Thompson's *Natural History of Vermont*, in 1853.

The term "Algonquin terrane" was also preoccupied by Desor, in 1851, as the designation of the fresh-water deposits about the Great Lakes, to which C. H. Hitchcock and J. D. Dana have since applied the term Champlain. The name "Algonkian" has been (in 1889) proposed by C. D. Walcott, for all the sub-Cambrian deposits down to the top of the crystalline schists. Thus a notable parallelism exists in the fortunes of the two terms proposed by Desor, for two distinct members of the Quaternary.

For a history of the use of the term "Laurentian as applied to a Quaternary terrane," see Joseph F. James in *American Geologist*, Jan. 1890. pp. 29-35; also C. H. Hitchcock, in *American Geologist*, April 1890, and Jules Marcou, in *American Geologist*, vol. VI, p. 64.

Various beds of crystalline magnesian limestone are described: —One on Eel lake 30 feet thick, and several other exposures on the same lake (pp. 83, 84); another on Long lake, seventh lot of ninth concession (with little magnesia), with apatite, silvery mica and graphite, and a few grains of rose-colored quartz, and some green serpentine; another below this, on Gold lake, with abundant grains and nodules of greenish serpentine; another, still lower, of white dolomite, with pinkish streaks and spots, with grains of quartz and serpentine (p. 84). Many other exposures are described, of similar general character. "Southwest from the Gold Lake limestone, in the continuation of the general strike, an exposure was met with on the fourth lot of the eighth concession. . . From the vicinity of this exposure, crystalline limestone is traceable, emerging from beneath the fossiliferous formations for a mile and a half" (p. 85).

If then these limestones are "low" in the gneissic series, an occurrence so near the fossiliferous limestones would imply the absence of a large part of the gneissic and the whole of the schistic rocks.

At an exposure on Birch lake, Mr. Murray measured a section, of which the following is a synopsis: (p. 89.)

11.	Mica slate, fine, with bands of coarse, disintegrating limestome	86ft.
10.	Limestone, coarse, disintegrating	40
9.	Feldspathic quartz rock and coarse disintegrating limestone	50
8.	Red, ferruginous mass, of brecciated appearance [See also p. 94]	10
7	Crystalline limestone, coarse, disintegrating	30
6.	Crystalline limestone, coarse, with graphite nodules and angular fragments of quartz	100
5.	Concealed from view	231
4.	Gneiss, mostly quartz, some black and brown mica and abundant garnets [Not very good gneiss]	260

3. White quartz and fine-grained feldspar alternating.	130
2. Supposed to be chiefly mica schist	300
1. Gneiss, red and gray, thin bedded, with layers of mica schist	132
	1369

1857. The reports of the Canadian survey for 1853, '54, '55, '56 were not printed until 1857.* In Murray's reports for 1853 and 1854, he describes the country between Georgian bay and the Ottawa river. "The Laurentian series" occupies most of the country. He speaks of *gneiss in alternation with mica slate*. Some highly garnetiferous portions are mostly an aggregation of granular quartz. He speaks also, of a black rock composed chiefly of hornblende, with some black mica (pp. 89, 90.) A fine grained red rock, supposed to be intrusive (p. 90) is spoken of, and beds of limestone are particularly located (pp. 91, 92, 93.) Bands of limestone are found about lake Nipissing (pp. 121, 122, 123.) The "Laurentian series" of lake Nipissing is further described in Murray's reports for 1855 and 1856 (Rep. 1857, pp. 140-3.)

"Among the boulders on lake Nipissing" says Mr. Murray, at the end of the report for 1855—printed in 1857, "many were observed to be of a slate conglomerate, and they were frequently of very great size; in their aspect and general character, these have a very strong resemblance to the slate conglomerate of the *Huronian series*,† from which, in all probability, they are derived" (p. 125.) In the report for 1856, he speaks of the bowlders of metamorphic rocks as derived from the Laurentian and Huronian formations on the north shore of lake Huron (p. 134.)

In reference to the red rock first mentioned in the report for 1853, (p. 90,) he says:

"At Grand Recollet Fall, in the north channel of the French River, and in the south channel about two miles southeast from them, the rock is of a brick red color, without any distinguishable lines or layers of stratification. It was supposed to be an intrusive syenite, and with a general breadth of from one to two miles, its course appeared to be N. N. W. and S. S. E., (141, 142.)

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*The volume printed in 1857, of 494 pages, contains reports of Murray and Hunt for 1853, 1854, 1855, and 1856, and reports of Mr. Billings and Mr. Richardson for 1856.

†The term "Huronian" is evidently employed in this place, as a geographical designation, rather than the name of a well-considered historical assemblage of rocks occurring in the Huronian area and elsewhere. Systemically, these rocks were understood by Sir William Logan, as he tells us, to belong to the Cambrian (See *ante*, p. 116, 1852, in *Rep* for 1851.) It will be remembered also, that Emmons had declared that they fall within the limits of the Taconic (See *ante*, p. 82, 1860, p. 18;) and it does not appear that the insistance upon the use of term Huronian has been formally defended—a lack of any attempt at justification which is explained only by the apparent assumption that the claims of Taconic were too preposterous to merit consideration.

Director Logan, in a note, suggests the resemblance of this red rock to some of the harder kinds of the *laterite* rock of the East Indies. He cites Dr. Clarke, as concluding, in 1838, that it results from decomposed syenite or hornblendic gneiss. "The Canadian rock," Mr. Logan adds, "seems to be a syenite in an incipient state of decomposition."

In his report for 1856, dated 1st March, 1857, Mr. Murray, speaking of the "distribution of the rock formations" between lake Nipissing and lake Huron, says:

"The rocks of the region explored during the season, embrace two of the oldest recognized geological formations, the Laurentian and Huronian; the rocks of the latter and more recent of which, have been observed to pass unconformably below the lowest of the fossiliferous strata of the Silurian system. The contorted gneiss of the Laurentian series, with its associated micaceous and hornblendic schists, spreads over the country to the south and east, while the slates, conglomerates, limestone, quartzyte and greenstone of the Huronian, occupy the north and western part" (p. 168). The boundary between the two coincides approximately with the White Fish river. The *immediate contact was nowhere distinctly seen* (168, 171). In passing "from the lower to the higher formation, a mass of rather coarse grained greenstone was generally met with." Mr. Murray gives, with many doubts, an approximate section of the Huronian series (p. 172), from which the following statement (omitting interpolated trap beds) is condensed:

6. Quartzyte, white and very pale sea-green, with beds of quartz conglomerate, the pebbles generally white opaque quartz, but sometimes red and green jasper.
5. Green, silicious, chloritic slates, and bands of quartzyte.
4. Slate conglomerate.
3. A band of limestone, much disturbed, often brecciated, pale whitish gray to dark blue.
2. Slate conglomerate, matrix always greenish, sometimes slaty, sometimes resembling a massive, fine grained greenstone; with many pebbles of white and red syenite, and occasional rounded masses of green, brown and red jasper.
1. Slate, fine grained, green, silicious with thin bands of green quartzyte; also, fine grained slates, sometimes greenish, often bluish or black, weathering very black; occasionally some layers of a reddish color.

The total thickness is supposed to be about 10,000 feet (p. 186). [illegible] of the rocks of this series are generally under 45°, but [illegible] from horizontal to 90°. The strikes vary from east northeast to west northwest. It appears to be a region of general disturbance. "An immense mass of magnetic trap" was found on White Fish lake. This is about midway between lake Wahnapitæ and island La Cloche in lake Huron, this, according to Hunt's analysis, contains "magnetic iron ore," magnetic iron pyrites" and "titaniferous iron." These facts remind one of the titaniferous and magnetic gabbro of northeastern Minnesota· Limestones are seen on the shore of lake Panache (p. 183). The eastern extremity of the La Cloche mountains is in a white or greenish quartzyte (p. 185).

Director Logan's report dated 3d March, 1857, after summarizing the work of Mr. Murray for the last five years, proceeds to trace the limestone beds of the "Laurentian Formation" in the neighborhood of Grenville and the Calumet river.

In a paper read before the American Association, in August, 1857,* by Sir William E. Logan "On the Division of the Azoic Rocks of Canada, into Huronian and Laurentian," he speaks of them confidently as "a series of very ancient sedimentary deposits in an altered condition." He refers to his suggestion of 1845, to separate the purely gneissoid portion from the portion consisting of interstratified gneisses and limestones, but says the evidence does not permit him to decide certainly which division is most ancient.

He next refers to what was published in the report of 1845, relative to the rocks on lake Temiscaming, consisting of silicious slates and slate conglomerates, overlaid by pale sea-green or slightly greenish-white sandstone, with quartzose conglomerates. The slate conglomerates are described as holding pebbles and bowlders (sometimes a foot in diameter) derived from the subjacent gneiss, the bowlders displaying red feldspar, translucent quartz, green hornblende and black mica, arranged in parallel layers which present directions according with the attitude in which the bowlders were accidentally inclosed. From this it is evident that the slate conglomerate was not deposited until the subjacent formation had been converted into gneiss, and very probably greatly disturbed; for while the dip of the gneiss, up to the immediate vicinity of the slate conglomerate, was usually at high angles, that of the latter did not exceed nine degrees, and the sandstone above it was nearly horizontal."

"In the Report transmitted to the Canadian Government in 1848, on the north shore of Lake Huron, similar rocks are described as constituting the group which is rendered of such economic importance from its association with copper lodes. This group consists of the same silicious slate and slate conglomerates, holding pebbles of syenite instead of gneiss; similar sandstones [quartzites?] sometimes showing ripple marks, some of the sandstones [quartzites?] pale-red green, and similar quartzose conglomerates, in which blood-red jasper pebbles become largely mingled with those of white quartz, and in great mountain masses predominate over them. But the series is here much intersected and interstratified with greenstone trap, which was not observed on Lake Temiscaming. These rocks are traced along the north shore of Lake Huron from the vicinity of the Sault Ste Marie, for 120 miles east." Sir William Logan continues, and indicates the existence of the same formation northeastward 130 miles farther, and as far as the Sturgeon river. The general bearing is northeast, and the dip appears to be almost northwest.

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* *Proc. Amer. Assoc. Adv. Sci.*, 1857, II, pp. 44-47.

It would be erroneous to suppose that director Logan intended, in the foregoing citation, to say that the gneiss is *immediately* "subjacent" to the slate conglomerate containing gneissic pebbles. No contact between the slate conglomerate and the subjacent gneiss had been reported and it was impossible to affirm that the formation here described was chronologically successive to the gneiss.

"The group on Lake Huron," he continues, "we have computed to be about ten thousand feet thick, and from its volume, its distinct lithological character, its clearly marked date posterior to the gneiss, and its economic importance as a copper-bearing formation, it appears to me to require a distinct appellation, and a separate color on the map. Indeed, the investigation of Canadian geology could not be conveniently carried on without it. We have, in consequence, given to the series, the title of *Huronian*."

"A distinctive name being given to this portion of the Azoic rock, renders it necessary to apply one to the remaining portion. The only local one that would be appropriate in Canada is that derived from the Laurentide range of Mountains, which are composed of it from Lake Huron to Labrador. We have therefore designated it as the *Laurentian* series.*

Thus a new meaning was given to the term "Laurentian series," which, since 1854, had included all the Azoic rocks.

At the same meeting of the American Association, Sir William Logan read a paper, "On the probable subdivision of the Lauren-

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*See also, *Canadian Journal*, 1857, ii. 439-442; *Canadian Naturalist and Geologist*, 1857, ii. 255-258.

tian series of rocks in Canada."[*] He described two beds of limestone which he had traced in the township of Grenville, on the Ottawa, running N. N. E., with indications that they belong to opposite sides of an overturned synclinal, with anticlinals of gneiss and quartz running parallel on the north and the south. A feature of these and other outcrops of limestone "is the occurrence immediately near the limestones, of immense masses of lime-feldspar. North of the Argenteuil band, eight miles examined across the stratification, consist almost entirely of it, in the form of Labradorite. . . Lime-feldspar is abundant at St. Jerome, and its stratified character is conspicuously displayed—the beds running parallel with the limestone. Mr. Hunt has traced a band of crystalline limestone for eleven miles, running diagonally across the township of Rawdon, in a north bearing. On the west side of this, lime-feldspar forms the great bulk of the rock exposures for twelve miles across the measures, and shows a well marked stratification."

"In Chateau Richer, below Quebec, a band of limestone occurs about a mile from the fossiliferous deposits, and to the northwest of it, lime feldspars present a breadth of eight miles. On an island near Parry's Sound, on Lake Huron, Dr. Bigsby observed the occurrence, *in situ*, of the opalescent variety of Labradorite, and the name of the mineral reminds us of the existence of the rock beyond the eastern end of the Province. It thus appears probable that a range of the rock will be found winding irregularly from one end of the Province to the other, of sufficient importance to authorize its representation by a distinct color on the map, and a distinct designation in geological nomenclature." [†]

1860. In a letter to M. Barrande, under date of December 31, 1860,[‡] Sir William Logan gives an exposition of the fauna of the Quebec group. Toward the end, he notes some recent observations which led him to qualify previous opinions in reference to the age of the Lake Superior sandstone:

"Mr. Murray has this season ascertained that the lowest rock that is well characterized by its fossils, in the neighborhood of Sault Ste Marie, near Lake Superior, really belongs to the Birdseye and Black River group, and that it rests on the sandstone of Ste Marie and Lacloche, the fossiliferous beds at the latter place being tinged with the red color of the sandstone immediately below them. These underlying Lake Superior rocks may thus be Calciferous and Potsdam, and may be equivalent to the Quebec group and the black colored shales beneath. The Lake Superior group is the upper Copper-bearing series of that region [consisting of 3. Potsdam; 2. Cupriferous; 1. "Slate conglomerates" etc., of lake Huron], and rests unconformably upon the lower Copper-bearing series, which is the Huronian system [as identified about Lake Superior] . . . Professor Emmons has long maintained, on evidence that has been much disputed, that rocks in Vermont, which in June, 1859, I for the first time saw and recognized as equivalent to the magnesian part of the Quebec group, are older than the Birdseye formation; the fossils which have this year been obtained at Quebec, pretty clearly demonstrate that in this he is right."*

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[*] *Proc. Amer. Assoc.*, 1857, Pt. II, 47-51; *Canadian Journal* 1858, II, iii, 1-5; *Canad. Natur.* 1857, ii, 270-274.

[†] Dr. J. J. Bigsby, nevertheless, has recorded the opinion that the Huronian and Laurentian systems are intimately related in lithological character and conformable position. The reference being especially to the north shore of lake Superior (*Quar. Jour. Geol. Soc.*. 1863, xix, 36-52).

[‡] *Canadian Naturalist and Geologist*, v. 472-7.

1863. No other record on the subject of pre-Silurian rocks appears to have been made by Sir William Logan until the publication of the Geology of Canada, in 1863. This convenient and copious synopsis of Canadian geology, has subsequently been cited for authority, instead of the original reports, and in consequence, geologists have fallen into some misunderstandings."†

"The rocks which compose the Laurentian mountains" writes Sir William Logan, "were shown by the Geological Survey, in 1846, to consist of a series of metamorphic, sedimentary strata underlying the fossiliferous rocks of the province. . . . They are altered to a highly crystalline condition, and are composed of highly feldspathic rocks, interstratified with important masses of limestone and quartzite. Great vertical thicknesses of the series are composed of gneiss containing chiefly orthoclase or potash feldspar, while other great portions are destitute of quartz, and composed chiefly of a lime-soda feldspar, varying in composition from andesine to anorthite, and associated with pyroxene or hypersthene. This rock we shall designate by the name of *anorthosite*."

It can hardly be said that the survey established the conclusion that these rocks were sedimentary in origin; but it pointed out frequently, the evidences of such an origin, and certainly caused it to appear probable. The anorthosite rock referred to above includes the belt of Labradorite described in 1857, which was made the ground of an "Upper Laurentian" or "Labradorian" division. Of this division nothing is said in the general report of 1863. Speaking of the orthoclase gneiss, the writer says:

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* This remarkable admission is alluded to by M. Barrande in these words "Terms so clear and possitive need no commentary. It is a formal recognition by Sir W. Logan of the Taconic system at the base of the lower Silurian. Professor Emmons could not wish the assent of a more respectable authority, which cannot fail to secure the adhesion of all American geologists ("Documens anciens et nouveaux sur la faune primordiale et le système Taconique en Amérique, Bull. Soc. géol. de France, Seance, de Fev. 4, 1861, p. 320), Sir William, nevertheless, said only that the shales and limestones of Quebec and Georgia are *subordinate to the Potsdam*—a formation which Dr. Emmons never claimed, though as we have seen, he consented to its inclusion in the Taconic.

† *Report of Progress from its Commencement to 1863.* Illustrated by 498 wood cuts in the text, and accompanied by an atlas of maps and sections. Montreal, 1863, 8-vo, pp. [illegible]

"A great portion of the rock is fine grained, and the constituent minerals are arranged in parallel layers; no one constituent predominates in any layer, to the exclusion of others; but even in their subordinate arrangement, there is an observable tendency to parallelism. . . . There is a never-failing constancy in respect to their parallelism which, however, though never absent, is sometimes obscure." . . . Coarse-grained beds of the character designated "granitoid gneiss," "might, on first inspection, be mistaken for igneous, instead of altered sedimentary masses. Upon a careful study of any such mass, however, it will be perceived that this reticulated structure is accompanied by an obscure arrangement of the meshes of the net-work into parallel lines which will be found conformable with the more distinctly banded portion of the strata" (p. 23).

"The greatest masses appear to be formed of the coarse-grained porphyroidal gneiss above described. These rise into the highest ridges and peaks of the orthoclase region, and generally constitute the main body of rock separating one important band of limestone from another. . . . The quartz occasionally presents masses of considerable volume, two of which, nearly pure, occur in the district of the Rouge, a tributary of the Ottawa, one 400, and the other 600 feet thick. The hornblende often forms a massive rock; a band of it in Blythfield has a thickness of 200 feet. Mica, associated with hornblende and with quartz, characterizes great thicknesses of hornblende and micaceous schists."

"Though there does not appear to be any special order in which the masses succeed one another, beds of hornblende rock, and hornblendic schist seem often to be more abundant near the interstratified bands of limestone than elsewhere, and in the same neighborhood, there usually occurs a more frequent repetition of beds of quartzite than in other parts. Near the limestones, pyroxene, which in other parts does not appear to be very abundantly disseminated, is occasionally met with, forming massive beds" (p. 24).

The writer describes the distribution of garnets in the gneiss, and of its passage, in one instance, into garnetiferous quartzite. The masses of limestone are described, sometimes becoming interstratified dolomytes. Serpentine is found associated with both. Pyrallolite, or rensselaerite often accompanies limestone; and pyroxene and hornblende are sometimes found disseminated in grains or crystals. Tremolite forms beds in it. Mica and graphite are both generally present. Pyrites is more abundant. Other minerals are chondrodite, apatite, fluorite and oxides of iron. The gneiss is sometimes greatly contorted, but the beds of associated limestone, even when very thin, are conformable with the beds of gneiss, and parallel with those bands and streaks with which they are marked (p. 27). One instance has been noted "where the limestone of a bed marked with grains of serpentine, appeared to have an uninterrupted connection with rock of an identical character filling up a crack or fault in the gneiss, at right angles to the general direction of the strata" (p. 28).

In a section measured at the High Falls of the Madawaska, a tributary to the Ottawa, here presented as an average section, there are 48 alternations of beds, in a total thickness of 1351 feet. In these, limestones occur six times, giving an aggregate thickness of 46 feet; quartzyte occurs once, in a bed ten feet thick; and "schistose gneiss" occurs five times, giving an aggregate thickness of 116 feet. At a higher position in the series, is said to be a bed of limestone 100 feet thick. At the Chenaux, there is more limestone than gneiss—there being a thickness of over 400 feet, of which not one-fifth is intercalated gneiss; while in Clarendon, similar rocks reveal "a thickness of 4000 feet, about two-thirds of which consists of crystalline limestone" (p. 31).

Another phenomenon of collateral interest, is thus pointed out:

"Notwithstanding the general highly crystalline condition of the Laurentian rocks, beds of an unmistakably *conglomerate* character are occasionally met with among them. . . . On the twenty-fourth lot of the tenth range of Bastard, a bed of conglomerate is interstratified between two beds of limestone. The dip of the strata at the spot is 30°, N. 50° E." The following is a condensed section:

		Feet.	Inches.
7.	Limestone, white, coarse	6	
6.	Limestone, arenaceous, fine, very hard		4
5.	Sandstone, calcareous, fine		2
4.	*Conglomerate*, the matrix a fine grained, quartzose sandstone somewhat calcareous, with white feldspar in grains and pebbles. Pebbles flat, lying on their sides	1	6
3.	Quartzite, calcareous-granular, with calcite		2
2.	Quartzite, coarse, translucent-granular, with feldspar and limestone		4
1.	Limestone, white, coarse, with graphite and mica	5	

In Madoc, *conglomerate* occurs again, with calcareous matter; and in a higher position is a ridge "consisting of micaceous schists, beyond which, for 300 yards, ridges of a decided *conglomerate*, with distinctly rounded pebbles, enveloped in a matrix of micaceous schist, alternate with ridges of schist containing few or no pebbles."*

"Still farther north, another band of *conglomerate* occurs, associated with fine grained, soft, micaceo-silicious, feldspathic schist. The matrix of the conglomerate weathers white, and appears to be a dolomite. The pebbles, of which the largest may be six inches in diameter, are chiefly quartz, but there are also, pebbles or masses of feldspar, and a few of calc-spar. The quartz pebbles are for the most part, distinctly rounded, and their colors various, some being internally bluish, some white, and others pinkish. The feldspar is red and white, and the calcspar white. The dip of the rocks appears to be southward of east, but the slope is irregular, and may probably be 35° or 40°" (p. 33.)†

The anorthosite rocks are fully described. Their bedding is very obscure, but they occur in belts conformable with the limestones and the orthoclase gneisses. The hypersthene rock of northern New York, and of the Isle of Skye, are pronounced of the same character. Near Bay Saint Paul, is a mass of titaniferous iron ore in the anorthosite, 90 feet in width, by about 300 feet in length (p. 35.)

The following is a synopsis of a general section across a portion of the Laurentian (p. 45:)

		Feet.
10.	Anorthosite above the Morin limestone (conjectural)	10,000
9.	Orthoclase gneiss (and a band of quartz)	3,400
8.	Proctor's Lake limestone	20
7.	Orthoclase gneiss	1,580
6.	Grenville limestone	750
5.	Orthoclase gneiss	3,500
4.	Great Beaver Lake and Green Lake limestone	2,590
3.	Orthoclase gneiss	4,000
2.	Trembling Lake limestone	1,500
1.	Orthoclase gneiss of Trembling Mountain	5,000
		32,750

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*Mr. Macfarlane subsequently describing these conglomerates, says they are "lithologically not unlike some of the Huronian rock." Whereupon, Sir W. E. Logan, in a note replies: "It is not to be inferred from the presence in them of a schistose conglomerate, that therefore, they are Huronian" (*Geology of Canada*, 1866, p. 93.)

†Sir William Logan never omits mention of these conglomerates, when having occasion to furnish a synopsis of the Laurentian. See, for instance, his announcement of organic traces (*Quar. Jour. Geol. Soc. Lond.*, Feb. 1865.)

In reference to the Huronian series, Sir William Logan makes statements from which the following extracts are drawn (p. 90:)

"On Lake Temiscaming, the Laurentian orthoclase gneiss is followed by a slate conglomerate. The finer parts of the rock are dark gray, weathering to dark green; they are of a uniform grain, and, being at the same time, argillaceous and silicious, they present the characters of a hard compact slate. Some parts not so fine in texture, are a hard, dark gray sandstone weathering to a dingy olive green. In both cases, the rock frequently exhibits the character of a compact conglomerate, holding pebbles and bowlders, sometimes a foot in diamater, of the subjacent gneiss, from which they appear to be principally derived."*

Some other conditions of the formation are described as finer textured, penciled in transverse fracture by fine colored lines; another as a "very close grained, compact, dark gray mica slate. When cleavage exists, the planes cut the pebbles in common with the matrix." It is never fit for roofing slates. To this slate conglomerate succeeds a quartzyte, apparently 400 to 500 feet thick.

"On the Sturgeon, Wahnapitæ and Whitefish rivers, there is usually interposed between the Laurentian gneiss and the recognized Huronian rocks, a mass of rather coarse grained greenstone or diorite."

The general section in the region of these three rivers, northeast of lake Huron, and stretching to lake Wahnapitæ—is represented by the following abstract (p. 52):

5. Quartzite, white and greenish, with beds of quartz conglomerate.
4. Slate conglomerate.
3. Limestone, much shattered and disturbed.
2. Slate conglomerate.
1. Silicious strata, fine grained, with greenish quartzite interstratified.

In the region nearer lake Huron, and along the northern shore westward, lies the typical part of the Huronian. As to its relations with the Laurentian, we have from the Canadian geologists, only the following information (p. 55):

"On the coast line, between the Mississagui and the Thessalon rivers, a distance of about 25 miles, the gneiss extends from within about four miles of the former, to within about the same distance of the latter; but, it is very much disturbed by intrusive granite and greenstone, and although there are great exposures of rock, it is very difficult to make out how the stratified portions are related to one another. The gneiss extends to the vicinity of a small stream, about a mile and a half above Les Grandes Sables, and what is supposed to be the lowest Huronian mass of that part, occurs about half a mile above the stream. It consists of a gray quartzite which *abuts against one mass of gneiss and runs under another*, and appears to be much broken by, and entangled among, the intrusive rock; but judging from a transverse measure in one part, its thickness would not be far from 500 feet. Farther west, after passing an exposure of stratified amygdaloidal trap, which would apparently overlie the [this] quartzite, the rocks for about two miles east of the Thessalon, appear to consist of green, fine grained chloritic and epidotic slate ["diabase slate"] alternating with masses that have the aspect of trap."

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*But it will be remembered that no contact between these so-called conglomerates and the older gneisses had been observed: nor has it to this day. Nor, if such observation had been made, would the circumstance prove these "conglomerates" in immediate chronological succession to the gneiss. Palæozoic limestones were frequently observed resting on gneiss, in the progress of the Canadian survey. The pebbles in this conglomerate may have been derived from the gneiss, and laid down on the gneiss, after the interposition of the events of a geologic age of land history.

The following is an abstract of the general section in this region (pp. 55–7):

		Feet.
13.	White quartzite	400
12.	Yellowish chert and impure limestone	200
11.	White quartzite, frequently vitreous	1,500
10.	Yellowish chert, with thin and very regular beds	400
9.	White quartzite, frequently vitreous	2,970
8.	Red jasper conglomerates. Sometimes fine white quartzite. Greenstones intercalated	2,150
7.	Red quartzite with interstratified greenstones	2,300
6.	Slate conglomerate with interstratified greenstones	3,000
5.	Limestone, compact, green, drab or gray, thin bedded	300
4.	Slate conglomerate [as previously described]	1,280
3.	White quartzite, sometimes pebbly	1,000
2.	Chloritic and epidotic slates [probably eruptive]	2,000
1.	Gray quartzite, thickness doubtful	500
		18,000

It will be desirable to contemplate the above section separately from the section of "Huronian" rocks reported from the north shore of lake Superior. It is quite possible that the two sections relate to rocks belonging to different geological ages.

"On lake Superior, the Laurentian gneiss is succeeded by slates generally of a dark green without, and often of dark gray in fresh fracture, which at the base appear occasionally to be interstratified with beds of a feldspathic character, of the reddish color belonging to the subjacent gneiss. Sometimes these beds are a combination of feldspar and quartz, occasionally with the addition of hornblende and, in some of the beds, the hornblende predominating, gives them a general green color. Some of the beds have the character of diorite; others, that of mica slate, and a few present that of quartzite" (p. 52).

These seem to be identical with the lowest rocks of the iron-bearing series of Vermilion lake, a part of Lawson's Keewatin. They exhibit the well-known transition from Laurentian gneiss to crystalline schists. The mica schist is "nascent."

"Rising in the series, the dark green slates become interstratified with layers holding a sufficient number of pebbles of different kinds, to constitute *conglomerates*. The pebbles appear to be all derived from altered rocks; they greatly vary in size in different places, and occasionally measure a foot in diameter. Where the *slate conglomerates* have been worn by the action of water, the pebbles are generally worn down equally with the rest of the surface; and though a very distinct picture of them is presented on such a surface, where the water or weather appears to have had an influence in bringing out a well defined contrast in colors between the pebbles and the slate, at the same time producing a contrast between parallel bands of the slate on the terminal edges of the laminæ, it yet often happens, unless the pebbles are of white quartz, that they are very obscurely distinguishable on fracturing the rock — both the pebbles and the matrix having a gray color, and showing very little apparent difference in mineral character. On some of these pictured surfaces, small opaque, white feldspathic crystals occasionally spot the whole surface of the rock — the pebbles equally with the slaty matrix. The rock has nowhere on the lake been observed to display true slaty cleavage, independent of the bedding; but it often exhibits a jointed structure, and the divisional planes cut through the pebbles without the smallest deflection."* (pp. 52 and 53).

It is impossible to identify this description with the description of the Huronian rocks north of lake Huron. There are some circumstances which readily explain the course taken by the Canadian geologists, but the identification made as early as 1848, has perpetuated misconceptions, and bred unintelligible confusion. I have some confidence that we may be near the solution of the puzzle.

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* The whole of the above description applies exactly to the lower part of the "Ogishke Conglomerate," on the shores of Ogishke Muncie or Kingfisher lake, in Minnesota, eighty miles west of Thunder bay. I shall return in the sequel, to a discussion of this identification. The stratigraphical position of the "Ogishke Conglomerate" has been in doubt; but if this parallelism is correct, it belongs near the bottom of the Vermilion lake iron-bearing schists.

The same basal slaty conglomerate occurs at other points along the north shore.

"A considerable thickness of these conglomerate or pebbly slates, is exposed at the mouth of the river Doré, near Gros Cap, about five miles above the mouth of the Michipicoten river. The strike of the rock is very regular, being about east and west, while the dip is highly inclined, the beds being not more than from ten to fifteen degrees from a vertical attitude; but the slope is for part of the distance, to the north, and for the remainder, to the south; there is not, however, supposed to be any repetition of the measures, which are given in descending order" (p. 53).

		Feet.
21.	Green slate rock, with a few scattered pebbles through some parts of it, in other parts conglomeratic; the sedimentary layers not distinctly marked; rock with a jointed structure; joints cutting straight through the pebbles............	40
20.	Green pebbly slate; edges of laminæ well marked, producing a ribboned appearance; pebbles chiefly gneiss, granite or syenite......................	300
19.	Green slate rock similar to 20 and 21.............	550
18.	Green pebbly slate..............................	170
17.	Measures covered by sand........................	90
16.	Green slaty conglomerate, with large pebbles of igneous or altered rock.........................	15
15.	Green slate rock with many pebbles..............	30
14.	Green slate with finer pebbles....................	40
13.	Green slate rock, with scattered, large pebbles....	10
12.	Green slate rock, like 13..........................	130
11.	Green slate conglomerate, with boulders sometimes a foot in diameter, in a slaty matrix............	5
10.	Measures concealed by sand......................	30
9.	Green slate rock with many pebbles..............	30
8.	Green slate rock with pebbles....................	30
7.	Measures concealed by sand........................	20
6.	Green slate rock, very pebbly, sedimentary layers finely waved, water worn surface much pitted...	30
5.	Green slate rock, bedding very even, appears to be somewhat talcose toward the top..............	20
4.	Green slate rock like 5...........................	15
3.	Green slate rock with even bedding, slightly unctuous and talcoid in several of the divisions.......	20
2.	Green slate rock, a few scattered pebbles in parts, flattened in direction of the strata.............	90
1.	Green slate rock with large pebbles and small boulders of granite or gneiss, quartz and a chert-like stone (p. 54).............................	35
		1,700

The foregoing section is almost a continuous "slate conglomerate," or pebbly slate, and but for the so-called "talcose" matter, might hastily be identified with the slate conglomerate of the Thessalon valley. But, as will be shown, it is a different slate. The descriptions again apply to the Ogishke conglomerate. In Minnesota, this conglomerate is only one member of the iron-bearing series. In accordance with that fact, Sir William Logan adds:

"At the Doré, a much larger amount of the slate formation than is here given comes in behind the preceding section; but it was so covered with trees and moss, at the time of the examination, that it was found impossible to follow out the details. Toward the lower part, it *assumes more the character of the gneiss* which usually succeeds it, and becomes *interstratified* with reddish-yellow feldspathic layers; but sufficient data have not yet been ascertained to determine what may be the total thickness of the slate rock in this part, though it must probably attain several thousand feet" (p. 54).

Other localities on lake Superior where slate conglomerates and jasper conglomerates occupy a similar position, are between the Goulais river and Batchewahnung bay. The same seem to extend along the shore of the Michipicoten river, on each side, eight or nine miles. It occurs also, a little farther west on the coast, and again about five miles south of Otter Head (p. 63).

"Another locality is Thunder bay, where they occupy the coast for a distance of ten miles, immediately below the mouth of the Kaministiquia river, on the north side, leaning in a narrow strip against the gneiss of the lower series. It is not improbable that they may present a narrow belt in the valley of the Kaministiquia They occupy the coast for about seven miles on each side of the New Pic river; while an interval from this to a point two miles beyond the Old Pic river, including the coast of Peninsula Bay and Harbor, and Pic island, is composed of trap. Beyond this, the chloritic slates occupy about fifteen miles of the coast, extending to the neighborhood of the deep cove which receives the Pike river" (p. 64).

A characteristic feature of the Keewatin iron-bearing series is indicated in the description of the junction of these rocks with the gneiss on the Kaministiquia river, in the vicinity of the Grand Falls:

"At the lower end of the portage, where the series makes its appearance, the rock resembles a massive syenite, in some parts red, and in others, whitish, but is probably a hornblendic gneiss in which the lamellar arrangement of the constituent minerals is obscure, as the rock gradually passes into such a gneiss. Resting on it *conformably*, there occurs a series of dark greenish blue, or greenish black slates, the one rock *passing almost imperceptibly into the other*. . . At each rapid part of the river above the Grand Falls, there is a greater or less development of these rocks, most frequently presenting the more distinctly stratified part of the gneiss. The best exposure of the slate is at the Three Discharges, about four miles above the Grand Falls, where the rocks are observed to pass from the gneiss to the slate." The vertical thickness at this place is about 2,300 feet.

"Toward the bottom, near the junction with the gneiss, the slates are of a bluish and occasionally of a brownish color. They are intersected by numerous parallel joints which divide the mass into rhomboidal forms of singular regularity. The middle and upper portions of the section are usually of a pistachio green, resembling the green of epidote, and frequently in part present a jaspery character. They are hard and compact, usually with a conchoidal, but sometimes with a splintery fracture. The divisional planes are frequently covered with mica, and in such cases, the rock may almost be termed a mica slate" (p. 65). Similar rocks continue as far as Dog lake.

The foregoing description applies perfectly to the passage from the iron-bearing formation to the gneisses, as observed in a hundred places in northeastern Minnesota. No structural unconformity exists, as a fact of present observation. It is not intended to assert, however, that it never existed.

The schists observed along the north shore of lake Huron, in which the Bruce and Wellington and Wallace mines were worked, constitute Logan's "Lower Copper-bearing series." As these were identified with the series of slates just described, they were also made to represent the Lower Copper-bearing series. Neither series could be identified with the copper rocks of the south shore of lake Superior. But as those rocks were observed on the north shore at a higher stratigraphic level, they were demoninated by Logan the "Upper Copper-bearing rocks." But in thus fixing parallelisms, he strangely overlooked the importance of a series between the proper Cupriferous rocks above and the pseudo-Cupriferous rocks below. These were the real Lower Copper-bearing rocks, though Logan joined them to the Upper, or south shore Cupriferous. His treatment of the so-called "Upper Cupriferous rocks" will appear from a few extracts.

"The Huronian formation of Lake Superior [the real iron-bearing series] is *unconformably* overlaid by a second series of copper-bearing rocks, which may be conveniently divided into two groups. Of these the lower consists of bluish slates or shales interstratified with sandstones and beds of columnar trap; and the upper, of a succession of sandstones, limestones, indurated marls and conglomerates, also interstratified with trap which is often amygdaloidal" (p. 67).

The following is a characterization of the lower group of the Upper Copper-bearing series, (p. 67):

"The base of the formation where seen in Thunder Bay, in contact with the subjacent green slates or slate conglomerates, presents conglomerate beds probably of no great thickness, composed chiefly of quartz pebbles, with a few of red jasper, and some of greenish, chloritic slate, in a greenish, arenaceous matrix, consisting of the same materials in a finer condition. These are followed by a set of very regular, even layers of chert, sometimes approaching a chalcedony, varying in color from nearly white, through different shades of gray to black, and in thickness, from less than half an inch to six inches, and even a foot. These are separated from one another by thin layers of dark gray dolomite, weathering rusty-red and present a striking ribbon-like appearance. Occasionally, thicker beds of dolomite occur, sometimes highly crystalline, separating aggregated bands of the ribbon-like strata; and these dolomitic beds, as well as the chert bands, are sometimes interstratified with argillaceous layers" (p. 67).

"In the vicinity of disturbed parts, the chert sometimes passes into chalcedony and agate, and small cracks are filled with what appears to be anthracite. Some of the chert bands appear to be made up of a multitude of minute, irregular, closely aggregated, sub-globular bodies, floating as it were, in the silicious matrix. Anthracite seems to be present in the centre of some of these, leading to the supposition that the color of the black chert, even where these shapes are not detected, may be owing to the presence of carbon. In some parts of these oölitic chert layers, small blood-red jasper spots occasionally become interstratified with the black. . . .

"Higher in the formation, argillaceous slates become interstratified with argillaceous sandstones in such an ealterd condition that it is often difficult, at first sight, to say whether the latter may not be trap layers. . . In some parts of the vertical thickness, calcareous layers are occasionally interstratified among the slates, but few of them are pure enough to be entitled to the appellation of limestones. . . "On the Kaministiquia, the lowest part of the formation occurs near Grand Falls. Its immediate junction with the rock on which it rests is concealed from view. . . The argillaceous strata visibly reach to within a short distance of the pond [in which the junction is supposed to occur] (p. 68).

"The general color of the rock is here black, weathering to a rusty brown. Some of the beds being soft and shaly, are easily decomposed by atmospheric influences, while the mass is, for the most part, a hard argillaceous slate. The whole formation appears to be more or less calcareous, and among the lower members, thin beds of magnesian limestone occur, sometimes alternating with thin beds of black chert" (p 68–9).

"In Thunder bay, and on the coast above it, trap bands, conformable with the stratification, are interstratified in several parts of the formation, but they occur in greatest thickness toward the bottom, not far above the chert-beds, and at the summit, overlying the whole of the mass. . . In all cases, the trap presents a very striking sub-columnar structure at right-angles to the plane of the stratification; and the crowning overflow gives a peculiar aspect to the whole region occupied by the formation to which it belongs. The overflow is from 200 to 300 feet thick, and the whole of the associated rocks, to the base of the formation, may possess a volume of between 1,500 and 2,000 feet." (pp. 69, 70).

The foregoing is a good description of the black slates and the slate-conglomerate of the so-called Huronian series north of lake Huron. In the latter region, columnar trap (or gabbro) does not constitute a persistent "crowning overflow", as far as the descriptions given by the survey indicate, but interbedded traps are present, and the lithological characters of the formation—the black shale, the cherty and flinty layers, the oölitic structure, the even beds, the proximate horizontality—and no other known formation about lake Superior presents any close resemblance to the Huronian strata. These black slates of Thunder bay, moreover, are now known to extend westward into Minnesota, and to overlie unconformably a mass of vertical, sub-crystalline schists in the same manner as at Thunder bay.

As to the upper group of the Upper Copper-bearing series, little needs to be said here, as this is the well known Cupriferous series of the south shore, consisting chiefly of intercalated beds of sandstone, conglomerate and trap, with occasional beds of limestone, and attaining an aggregate thickness of 6,000 to 10,000 feet. The trap is often amygdaloidal, and native copper occurs in irregular grains and strings and masses up to ten pounds in weight. Sir William Logan's discussion of this formation does not possess theoretical significance.

In an appendix to the report of 1863, Sir William Logan states that "the Taconic system of Emmons, which he supposed to be a distinct series of rocks more ancient than the Potsdam, appears to consist, for the greater part at least, of the strata of the Potsdam and Quebec groups. The Upper Copper-bearing rocks of lake Superior are regarded as occupying the position of the Quebec group, to which they bear some resemblance in lithological and mineralogical characters. They may, perhaps, include the Potsdam group."* [Compare the views of Foster and Whitney.]

The following is a summary of Sir William Logan's successive views on the classification of the Azoic rocks of Canada:

<table>
<tr><th colspan="5">DIVISIONS OF ARCHÆAN ROCKS RECOGNIZED BY LOGAN.</th><th>PUBLICATION.</th></tr>
<tr><td colspan="5">Metamorphic Series.</td><td>1845.</td></tr>
<tr><td colspan="2">Lower Group.</td><td colspan="3">Upper Group (Lake Sup).</td><td>1846.</td></tr>
<tr><td colspan="2">Gneiss, Mica slate.</td><td colspan="3">Quartz rock, etc.</td><td>1847.</td></tr>
<tr><td colspan="5">Granitic or Metamorphic Group.</td><td>(1848) 1850.</td></tr>
<tr><td colspan="5">Metamorphic or Gneissoid Group.</td><td>(1849) 1850.</td></tr>
<tr><td colspan="5">Metamorphic Group.</td><td>1851.</td></tr>
<tr><td colspan="2">Gneiss, etc.</td><td colspan="3">Cambrian.</td><td>(1851) 1852.</td></tr>
<tr><td colspan="5">Laurentian Series.</td><td>(1852) 1854.</td></tr>
<tr><td colspan="2">Laurentian Formation.</td><td colspan="3">Huronian Series (Murray).</td><td>(1853-7) 1857.</td></tr>
<tr><td>Laurentian</td><td>Upper Laurentian. or Labradorian.</td><td colspan="3">Huronian.</td><td>1857.</td></tr>
<tr><td colspan="2">Laurentian.</td><td>Huronian. (Lower Copper bearing rocks.)</td><td colspan="2">Upper Copper-bearing rocks.</td><td>(1863).</td></tr>
<tr><td colspan="2" rowspan="2">Laurentian Series.</td><td rowspan="2">Huronian Series.</td><td colspan="2">Upper Copper-bearing rocks. (Quebec group)</td><td rowspan="2">1866.</td></tr>
<tr><td>Lower group</td><td>Upper group</td></tr>
</table>

NOTE.—Dates of presentation of reports are placed in parentheses.

One of the important features of the volume on the Geology of Canada, 1863, was the introduction of the "Quebec Group," supposed to be a group of strata occupying a position between the characteristic part of the Calciferous and the Hudson River shales, and specially investigated in the vicinity of Quebec. Sir William Logan was so good a physical geologist that when he had given his sanction to the proposal, a strong predisposition was given to American opinion. Thus the Quebec group had the sanction of James Hall, E. Billings and T. S. Hunt, and found admission to the second edition of Dana's "Manual of Geology." We have seen, however, what misgivings on the subject were entertained by professor Hall, and how he permitted his respect for Sir William Logan to compromise his own palæontological convictions. The "Group" remained a stumbling-block and an enigma in American geology until, failing in prestige during the last decade, it received its final *coup de grace* at the hands of the Survey itself, in 1889.†

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*Geology of Canada. 1863, p. 934.

†Second Report on the Geology of a portion of the Province of Quebec. R. W. Ells. *Geol. Sur. Canada, Annual Report*. 1887-88. Montreal 1889.

It would be profitless to pursue the history of an opinion which has already lost its hold on credence, even if were the purpose of the present memoir to deal with discussions exclusively palæontological. But the rocks have been, in some regions, so confounded with those of the so-styled Taconic, that the investigation of the latter involves a review of opinion on the former. For the convenience of the student, therefore, the titles of the principal papers bearing on the discussion, are here appended*

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*1861. Logan, Sir W. E.
In "Correspondence of Joachim Barrande, Sir William Logan and James Hall, on the Taconic System, and the Age of the Fossils found in the Rock of northern New England and the Quebec Group of Rocks." *Amer. Jour. Sci.* II, xxxi. 210-226.
1862. Logan, W. E.
Determination of Age of Quebec Rocks. *Amer. Jour. Sci.*. II, xxxiii, 105-6.
1862. Logan, W. E.
Considerations relating to the Quebec Group and the Upper Copper-bearing Rocks of Lake Superior (Read before Montreal Nat. Hist. Soc.). *Amer. Jour. Sci.*, II, xxxiii, 320-327.
1863. Logan, W. E.
The Quebec Group. *Geology of Canada*, 1863, pp. 225-397.
1863. Logan, Sir W. E.
Letter addressed to Mr. Joachim Barrande, on the Quebec Group at Point Lévis, Montreal, pp. 1-14. Reprinted, *Amer. Jour. Sci.*, II, xxxvi, 366-377.
1866. Logan, Sir W. E.
The Quebec Group and its Divisions. *Canada Report*, 1863-6, pp. 4-6.
1866. Richardson, James.
Divisions of the Quebec Group. *Canad. Rep.*, 1863-6, pp. 29-34.
1870. Richardson, James.
Report on the South Shore below Quebec [Rocks of the Quebec Group]. *Canad. Rep.*, 1866-1869, pp. 119-149.
1873. Selwyn, A. R. C.
Note of a Preliminary Geological Reconnoissance from Lake Superior by the English and Winnipeg rivers to Fort Garry [Compared with Quebec]. *Canad. Rep.* for 1872-3, pp. 8-18.
1879. Selwyn. A. R. C.
Report of Observations on the Stratigraphy of the Quebec Group and the Older Crystalline Rocks of Canada. *Canad. Rep.*, 1877-8, A, pp. 1-15.
1883. Adams, Frank D.
Notes on the Microscopic Structure of some Rocks of the Quebec Group. *Canad. Rep.*, 1880-82, A. pp. 8-23.
1887. Ells, R. W.
Report on the Geology of a portion of the Eastern Townships of Quebec. *Canad. Rep.* 2d Ser. Vol. II. 1866, J. pp. 1-70.
1888. Ells, R. W.
Second Report on the Geology of a portion of the Province of Quebec. *Canad. Rep.* 1887-8, Vol. III, Pt. 1. K, pp. 1-120.
1890. Ells, R. W.
The Stratigraphy of the Quebec Group *Bull. Geol. Soc. Amer.*, I. 453-468.
1890. Brainerd, Ezra and Henry M. Seely.
The Calciferous Formation in the Champlain Valley. With a Supplement on the Fort Cassin Rocks and their Fauna, By R. P. Whitfield. *Bull. Geol. Soc. Amer.*, I, 501-516.
1890. Walcott, C. D.
A review of Dr. R. W. Ells' Second Report on the Geology of a Portion of the Province of Quebec, with Additional Notes on the "Quebec Group." [History of Views] *Amer. Jour. Sci.*, III., xxxix, 101-115.
1890. Hunt, T. Sterry.
The Geological History of the Quebec Group. *American Geologist*, Vol. iv, p. 212.
See, also, the references on the Taconic System, many of which bear on the Quebec **Group.**

JOSIAH D. WHITNEY.

1847. Josiah D. Whitney and Joseph W. Foster were assistants, in 1847, of Dr. C. T. Jackson in his survey of the "mineral lands" of lake Superior; and Mr. Whitney continued in the same capacity in 1848. In 1849 and 1850, Messrs. Foster and Whitney succeeded Dr. Jackson, and their Annual Report is dated Boston, Nov. 5, 1849. Mr. Whitney's observations in 1847, were restricted to the copper-bearing rocks, mostly of the Ontonagon district, and he had no occasion to introduce general views in his report; but a part of Mr. Foster's notes relate to a traverse from lake Superior over the Menominee region, to Green bay.[*] Mr. Whitney does not appear to have transmitted to Dr. Jackson, anything except barometric observations as the result of work in 1848 (*op. cit.*, pp. 644-646).

1849. In their report of 1849, Messrs. Foster and Whitney say: Experience "has demonstrated that the veins of copper and its ores in the sandstone and conglomerate are not to be relied on, and that when worked even to an inconsiderable depth, they give out. . . All the productive lodes are confined to the ranges of trap. . . The associated sandstone and conglomerate belong to the Silurian system, and rest at the base of all the fossiliferous rocks" (p. 607.)[†] Accompanying this report are four geological maps: 1. Ile Royale; 2. Keweenaw Point; 3. The district between Keweenaw Bay and Chocolate River; 4. The district between Portage Lake and Montreal River. On the 3d and 4th of these Maps, the term "Azoic" is introduced. The 4th Map was transmitted to the Secretary of the Interior by a letter dated July 25th, 1849. The date of transmittal of the other is not known, but probably, the same month. On the 3d Map, the explanatory legend presents the following arrangement:

Aqueous,	Base of the Silurian System,	Sandstone.
Metamorphic,	Azoic System,	Quartz. Saccharoidal limestone Schistose Rocks.

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[*] The Report is found on pp. 773-784 of that chaos of literary, scientific and statistical matter called Jackson's Geological Report, occupying pages 371-801 of "*Annual Messages and Documents*," 1849-50, Part III—except pages 605-624, including four maps, occupied by Foster and Whitney's report for 1849, which is interjected into the midst of Jackson's report.

[†] Dr. Jackson, (*op. cit.* p. 399), says "Anterior to my researches, the red sandstones of Lake Superior were supposed to be the "old red," and subsequently the opinion that they belonged to the Potsdam, N. Y., series, gained ground; but, from the facts that the mineral composition, associations and contents were identical with the sandstones of Nova Scotia, Connecticut, Massachusetts and New Jersey, and that the disturbing agency which moved them was in the same direction and produced similar, if not identical results, I was disposed to regard those rocks as of the same age, or as of the New Red sandstone series. This idea has been confirmed."

Igneous Formation,	More recent than the Azoic, but older than the Silurian,	Trappean Rocks. Granite. Basalt.

The legend on the 4th Map is as follows:

Aqueous Formation,	Lower Silurian System.	Lower Magnesian Limestone. Sandstone. Conglomerate.
Metamorphic,	Azoic System,	Schistose Rocks.
Igneous,	Contemporaneous with Silurian,	Trap. Jasper and Quartzose Porphyry.
	More recent than Azoic,	Granite.

1850. The first part of the final report, relating to the "Copper Lands," was transmitted April 15, 1850.* In the IVth chapter, the authors, treating of "Stratified and Sedimentary rocks," comprise them under three general divisions:

III. Compact or Lower Magnesian Limestones. 3. Birdseye and Black river limestone; 2. Chazy limestone; 1. Calciferous sandstone.

II. Inferior Sandstone. Potsdam Sandstone.

I. Conglomerate. Not strictly a sedimentary rock, but a volcanic tuff.

Speaking more particularly of the conglomerates, the authors state concerning the pebbles: "Their surfaces do not present that smooth, polished appearance which results from the attrition of water,† in fact, a close observer can readily distinguish between those which have been recently detached from the rock and those which have been for a time exposed to the recent action of the surf. The conglomerate appears to have been formed too rapidly to suppose that the masses were detached and rounded by the action of waves and currents, and deposited with silt and sand on the floor of the ancient ocean; for while the contemporaneous sandstone remote from the line of volcanic foci, does not exceed three hundred or four hundred feet in thickness, the united thickness of the conglomerate bands, in the vicinity of the trappean range on Keweenaw Point, exceeds five thousand feet. As we recede for a few miles from the line of the volcanic fissure, these amygdaloidal pebbles disappear, and are replaced by arenaceous and argillaceous particles. We are therefore disposed to adopt the theory as to the origin of such masses first suggested by Von Buch: 'When basaltic islands and trachytic rocks rise in fissures, friction of the elevated rock

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***Report on the Geology and Topography of a Portion of the Lake Superior Land District in the State of Michigan.* By J. W. Foster and J. D. Whitney, United States Geologists. In two parts. Part I, Copper Lands. Washington, 1850, 8vo, pp. 224, with a Map and xii Plates. (Being *Ex. Doc.* No. 69, House of Representatives, 31st Cong, 1st Sess.)

†The "attrition" which rounds shore pebbles is not "attrition of water". Perhaps the authors mean attrition *in* water.

against the walls of the fissures, causes the elevated rock to be enclosed by conglomerates composed of its own matter. The granites composing the sandstones of many formations have been separated rather by friction against the erupted volcanic rock than destroyed by the erosive force of a neighboring sea. The existence of these friction conglomerates, which are met with in enormous masses in both hemispheres, testifies to the intensity of the force with which the erupted rocks have been propelled from the interior through the earth's crust. The detritus has suddenly been taken up by the waters, which have then deposited it in the strata which it still covers'.* Those pebbles having a highly vesicular structure may have been ejected through the fissures in the form of scoriæ while in a plastic state, and have received their rounded shape from having been projected through water—on the same principles as melted lead when dropped from an elevation assumes a globular form '.†

On page 112, in a note, the authors cite similar conglomerates of eruptive origin, in the Hawaiian and Fiji islands, as described in the report by professor Dana, on the Geology of the Exploring Expedition.

In speaking of the sandstone, they do not, like Houghton, discriminate between that which is interbedded with conglomerate layers, and that which overlies both, though they recognize, as Houghton did, the synclinal arrangement of the beds forming the lake basin, and give a theoretical diagram illustrating it. They say: "During the deposition of the sandstone, numerous sheets of trap were ejected and flowed like lava streams, and the igneous and aqueous products were so intermingled as to present the appearance of having been derived from a common origin." (p. 110.) The general discussion, however, relates to that which Houghton had denominated "Lower or Red Sandstone."

The method of geologic action which gave origin to the Cupriferous formation is conceived by the authors as follows: The entire region was the bed of an ocean of heated waters, and volcanic paroxysms were frequent. Numerous fissures through the crust of the earth resulted. "Along the lines of these fissures existed numerous volcanic vents, like those observed at this day in Peru, Granada and Java, which were characterized by periods of activity and repose. From these vents were poured forth numerous sheets of trap, which flowed over the sheets of sand and clays then in progress of accumulation. During the throes and convulsions of the mass, portions of rock would become detached, and rounded simply by the effects of attrition, and jets of melted matter be projected as volcanic bombs through the air or water, which on cooling would assume spheroidal forms, while other portions of the rock, in a state of mechanical division, would be ejected in the form of ashes and sand, which mingling with the water, would be deposited, as the oscillations subsided, among the sand and pebbles at the bottom of the sea. During the whole of this period of volcanic activity, the sands which now form the base of the Silurian system were in progress of accumulation, and became mingled with these igneous products" (p. 120). "Thus, alternating bands of igneous and aqueous rocks were formed", and thus, unlike the theory of Dr. Houghton, which regarded the trap sheets as dykes, our authors contemplate them as overflows.

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*Geognostische Briefe, S. 75-82.

†Report on Copper Lands, pp. 99, 100.

1851. The second part of Foster and Whitney's report on the Mineral Lands of Lake Superior[*] was transmitted to the secretary of the Senate, November 20, 1851. It is a comprehensive, thorough and scientific presentation and discussion of the general and economic geology of the region embraced — with the exception of matters treated in Part I. It is probably the most meritorious production to that time issued under the auspices of the general government. The lithographed engravings are superior, but the wood-cuts are obscure, and the typography and paper cheap and unworthy. This volume has become celebrated as the one in which the "Azoic System" was established in America.

In the preliminary chapter, a general classification of the rocks of the district is given, of which the following is the lower part :[†]

Aqueous.	Silurian System.	Potdsam Sandstone,[‡] etc.	
Metamorphic.	Azoic System.	**Beds of Quartz and Saccharoidal Marble. Chloritic, Talcose and Argillaceous Slates Gneiss, Mica and Hornblende Slate.**	
Igneous.	Of various ages.	**Trappean** volcanic rocks.	**Masses of Specular and Magnetic Oxide Iron. Hornblende and Serpentine rocks. Basalt, Amygdaloid, Greenstone or Dolerite Porphyry.**
		Plutonic rocks.	**Feldspar and Quartz rock. Syenite. Granite.**

"Below all the fossiliferous groups of this region" say the authors, "there is a class of rocks consisting of various crystalline schists, beds of quartz, and saccharoidal marble, more or less metamorphosed, which we denominate the Azoic system. This term was first applied by Murchison and De Verneuil[*] to designate those crystalline masses which preceded the Palæozoic strata. In it, they include not only gneiss, but the granitic and plutonic rocks by which it has been invaded. We adopt the term but limit its signification to those rocks which were detrital in their origin, and which were supposed to have been formed before the dawn of organized existence.[†]

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[*] *Report on the Geology of the Lake Superior Land District.* By J. W. Foster and J. D. Whitney, United States Geologists. Part II, The Iron Region, together with the General Geology, March 13, 1851: Ordered to be printed, Washington, 1851 [8–vo., pp. 406, 36 plates of illustrations, and a geological map of the upper Peninsula of Michigan and of the north shore of lake Superior from Sturgeon bay eastward.]

[†] It will be remembered that in all the stratigraphic tables of the present memoir, the older rocks stand below. This is an inversion of the arrangement adopted by Foster and Whitney, and most of the earlier writers.

[‡] The age of the Potsdam sandstone was discussed by the authors in *Proc. Amer. Assoc.*, Cincinnati meeting, 1851. (pp. 22-38).

Obviously, there is a degree of indefiniteness about this definition: 1st. Remains of organization may be found in rocks which "preceded the Palæozoic" as understood by Murchison: 2d. Not only gneiss but granite and syenite may yet be proven of detrital origin. Thus the base of the Palæozoic may be lowered either by the discovery of fossiliferous rocks between the Potsdam and the top of the Azoic as known to Foster and Whitney, or by the discovery of fossils within the Azoic rocks as thus known; and the base of the Azoic may be raised by the demonstration of the original igneous condition of the gneisses, or lowered by the demonstration of the original sedimentary condition of the granitoid masses. These, however, are only practical difficulties in the application of the conception of Foster and Whitney. The conception as above defined is clearly delimited and rational. By a reasonable application of the conception, the Azoic system would always embrace the strata beneath the oldest at any time found to be fossiliferous[‡] and above the rocks at any time held to be igneous in origin. This was very nearly Emmons' first conception of the Taconic, nine years earlier; but he recognized the Potsdam sandstone as the base of the Silurian system, and only by provisional inference, the base of the Palæozoic series so that when strata older than the Potsdam were found fossiliferous, he changed his view in reference to the azoic character of the Taconic, and thereafter insisted that it was a zoic system.

"Most of these rocks [of the Azoic system,] the authors state, "appear to have been of detrital origin, but greatly transformed by long exposure to heat. They are sub-crystalline or compact in their structure, and rarely present unequivocal signs of stratification. They exhibit the most violent dislocations; in one place the beds are vertical, in another, reversed, and in another, present a succession of folded axes. Intermingled with them is a class of rocks whose igneous origin cannot be doubted, and to whose presence, the metamorphism so characteristic of this series, is in some measure to be ascribed. They consist of varying proportions of hornblende and feldspar, forming traps and basalts, or, where magnesia abounds, pass into serpentine rocks. They appear in some instances to have been protruded through the pre-existing strata, in the form of dikes or elvans, in others, to have flowed in broad lava streams over the ancient surface; and in others, to have risen up through some wide-spreading, expanding fissure, forming axes of elevation" (p. 8).

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[*] *The Geology of Russia in Europe and the Ural Mountains*, vol. i, p. 10, 1845,. See also, *Proc. Geol. Soc. Lond.*, vol. iv, p. 602, 1845.

[†] Foster and Whitney, *Rep.*, p. 3.

[‡] Mr. Whitney has indicated the possibility that the upper limit of the Azoic might have to be placed lower than the base of the Potsdam sandstone. "If we find in this country, a series of fossiliferous beds below those at present recognized, and whose organic contents cannot be considered as being of Lower Silurian type, let us give them a new name which shall not involve us in any Cambrian controversies." (*Amer. Jour. Sci.*, II, xxiii, p. 314).

"Many eminent geologists maintain that the lowest stratified rocks are but portions of the Silurian or Cambrian system; and that from long continued exposure to heat the lines of stratification have become obscure, and all traces of organic remains obliterated. Our investigations in this district have led us to a different conclusion. If the Potsdam sandstone rests at the base of the Palæozic series; if from that epoch we are to date the dawn of animal creation, there is in this district a class of obscurely stratified rocks interposed between the Silurian system and the granite—rocks distinct in character, unconformable in dip, and destitute of organic remains" (p. 10).

The authors quote from the early reports of "Mr. Logan, the distinguished Provincial geologist of Canada, for the purpose of stating that the two-fold division of these rocks, described by Mr. Logan* has not been observed on the southern shore.

In reference to the blending of igneous and sedimentary characters in the Azoic rocks of the south shore, the authors quote from de la Beche a passage which, though it possesses only the authority of an individual, needs to be borne in mind in the more recent attempts to interpret the rocks in question, whether on the south or the north shore. This is the passage:

"There is so intimate a mixture of compact and schistose trappean rocks with the argillaceous slates [of Bossiney, Cornwall] that the whole may be regarded as one system, the two kinds of trappean rocks having been probably erupted, one in a state of igneous fusion, and the other in that of an ash, during the time that

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*Report of Progress, 1846-7, p. 10. It is clear that the upper division here indicated in the metamorphic rocks is what was afterward denominated *Animike*. But we shall return to this point. It is also apparent that this division, if not entirely wanting on the southern shore, is very inconspicuously developed.

the mud now forming slates, was deposited; the mixture being irregular from the irregular action of the respective causes which produced them, so that, as one may have been derived from igneous action, and the other from the ordinary abrasion of pre-existing solid rocks, they were geologically contemporaneous."

Some further remarks by the authors relate specifically to the rocks on the south shore of lake Superior. "Many of the igneous rocks of this region form neither long lines of dykes nor axes of elevation, but broad sheets, bearing the same relation to the slates that the trappean bands of Keweenaw Point do to the conglomerates. Many of the slates appear to be composed of pulverulent greenstone, as though they might originally have been ejected as an ash, and subsequently deposited as a sediment, and pass by imperceptible gradations from a highly fissile, to a highly compact slate." Some of these phenomena are compared with sub-oceanic salses, "pouring forth streams of pulverulent material to be mingled with ordinary fragmental deposits.

Messrs. Foster and Whitney, in concluding their account of the general geology of the Azoic system, seek to strengthen its establishment by pointing out the existence of a similar series of rocks in other states—in Minnesota, Arkansas, Missouri, New York, Pennsylvania and Virginia. They refer to the evidence supplied by the brothers Rogers, that the series of obscurely stratified rocks known as the gneissoid series, flank the Appalachian chain on the east throughout its entire extent. Turning to the Old World, they cite the well known witnesses to the existence of similar azoic rocks in Scandinavia, Great Britian and Bohemia (pp. 33, 34.)

As to the origin of the mass of magnetic oxides of iron, having shown that they occur in beds instead of true veins, they consider the evidences of an igneous and of a metamorphic origin, and conclude: "On the whole, we are disposed to regard the specular and magnetic oxides of iron as a purely igneous product, in some instances poured out, but in others sublimed, from the interior of the earth. . . Where these ores occur in a state of almost absolute purity, in the form of vast irregular masses, occupying pre-existing depressions; or where the incumbent strata are metamorphosed and folded over them; or where they are traversed by long lines of ferruginous matter in the form of dykes—there can be little doubt that these ores have risen up in a plastic state from below.

"Where they are found impregnating metamorphic products, such as jasper, hornstone or chert, quartz, chlorite and talc slate, not only interposed between the laminæ, but intimately incorporated with the mass, giving it a banded structure, we regard it as the result of sublimation from the interior."

"When they are included in metamorphic strata, in the form of beds of variable width, with a conformable range and dip, and with minute particles of the associated rock mechanically mixed with the ore, we are disposed to regard them as the result of aqueous deposition, although the materials may have been derived from the ruins of purely igneous products" (p. 68.)

In *1857*, Sir William Logan and the Canadian geologists having recognized two distinct systems beneath the Potsdam sandstone, Mr. Whitney returned to the defence of the systemic unity of the sub-Silurian rocks, and of the system which he and Mr. Foster had proposed to receive them.* Mr. Whitney thinks this divergence of opinion is "due entirely to a different understanding of the origin and relations of the cupriferous formation of lake Superior and especially of that portion of it which belongs to the southern shore of the lake" (p. 306.) He proceeds accordingly, to establish the proposition that the cupriferous series of interbedded traps, conglomerates and sandstones are collectively the equivalent of the sandstone extending generally along the south shore. This being so, nothing remains between the cupriferous series and the granite except the indivisible series of rocks which Foster and Whitney had styled the Azoic system.

If we follow Mr. Logan, he says in effect, we must admit that the cupriferous belt lies unconformably beneath the sandstone.

"We must also admit that these cuperiferous rocks are identical in age with the series of quartz beds and jasper conglomerates displayed on the north shore of lake Huron, and hence called 'Huronian.' Therefore, according to Mr. Logan's views, since the cupriferous series of lake Superior rests unconformably on a still lower formation of shales, quartz rock, etc., the rocks of lake Huron must also do the same, although no such fact has been observed. Hence, we must recognize two systems beneath the Potsdam sandstone, one the Huronian, comprising the cupriferous rocks of lake Superior and the formations of the north shore of lake Huron, the other, the Laurentian, including all the rocks of Canada and the Northwest which we should designate by the term 'Azoic,' with the exception of those of lake Huron, as before indicated."

"The principal question to be settled then, is this: What are the relations of the cupriferous rocks of lake Superior? Do they

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*J. D. Whitney, "Remarks on the Huronian and Laurentian systems of the Canada Geological Survey," *Amer. Jour. Sci.*, II, 305-304, May, 1857.

constitute a distinct system by themselves, or are they part and parcel of the Potsdam sandstone itself?" And this is the question which Mr. Whitney proceeds to answer affirmatively. Mr. Whitney's two main positions as against those of Sir William Logan, may be stated thus:

1. The cupriferous formation is *not* distinct from the Potsdam.
2. The Huronian rocks are *not* equivalent to the cupriferous.

In *1884*, professor Whitney again returned to a vindication of the integrity of the Azoic system.* In an extended and elaborate memoir, Messrs. Whitney and Wadsworth review all that had been written in America on rocks embraced under the Azoic system. They pursue the method of liberal quotation in setting forth the views of the various writers, and accompany these by critical remarks. The authors find very little to commend in this literature, but discover many opportunities for caustic comment, seeming almost to forget that possibly the honest search for truth may not lie, precisely in an adoption of the views of the originators of the Azoic system. Still there is a good amount of justice in the following sentence, extracted from their "Resume:"

"We think that it is impossible for any unprejudiced worker in this department of science to peruse with care the preceding pages, and not feel obliged to admit that the geology of a large portion of this country, and especially that of Canada and New England, is in an almost hopeless state of confusion. We thing that it must have been made clear to the candid mind, that the geologist would find himself completely baffled, who should endeavor to obtain any definite knowledge of the real nature and order of succession of the rocks which cover so large a portion of the region in question, from the study of that which has been published with regard to them. We believe that we are justified in going still farther, and saying, that our changes of our having, at some future time, a clear understanding of the geological structure of northeastern North America would be decidedly improved, if all that has been written about it were at once struck out of existence" (pp. 519-520.)

All this tends to prove, as the authors think, that no real progress has been made in azoic geology since 1850. Their impressive resumé embraces the following positions: *First*, No evidence has been presented of the existence of life anterior to the advent of the primordial fauna of Barrande—that is, in those metamorphic rocks which were at first united in a system styled "Azoic." The supposed organism known as *Eozoön*, is only a peculiar arrangement of crystalline matter. Its organic nature was never consistently defended by Dawson and Carpenter. The segregated, veinlike character of the limestones in which it occurs in eastern Massachusetts, has been affirmed by Burbank, Perry and Dr. Wadsworth, and the final *coup de grace* has been administered by Dr. Möbius. The epitaph has been written by F. Römer and Zittel. As to the organic origin of the crystalline *limestones*, there is nothing whatever to prove it, while the presene of calcite and calcitic formations in metalliferous veins, and in dykes and amygdaloids is sufficient proof that the existence of a limestone does not necessarily imply conditions compatible with organization. *Graphite*, too, instead of being a derivative of vegetable substances is found in the presence of indications of intense heat, and has never been found in such situation as to justify the inference that it resulted from the transformation of coal. As to the origin of masses of *magnetic and specular oxides of iron*, there is nothing in the laws of chemistry to forbid their eruptive nature, while the distribution of iron in meteorites and on the earth, and the evidences touching the mineral nature of the earth's interior, all tend to show the probability that the iron of the earliest times was connected with the agency of heat rather than of organization.

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* *The Azoic System and its Proposed Subdivisions.* By J. D. Whitney and M. E. Wadsworth. *Bull. Mus. Comp. Zoöl.*, Geological Series, vol. i, pp. xvi and 331-565.

Secondly, As to the admissibility of a subdivision of the azoic rocks, the authors maintain that no adequate ground has yet been presented. They moreover, preclude the possibility of such ground by laying down the canon that observed successions of life are the only justification of a chronological arrangement of rocks. Of course, no successions of life are possible where no life exists. To pronounce a series azoic and demand the application of the palæontological dogma, is to move the previous question without debate. Whether there are or may be, good grounds other than palæontological, for a successional arrangement of terranes, is a question which will be considered in the sequel of this memoir. The mineralogical and lithological bases of various proposed divisions of the Azoic are examined, and besides their exclusion at the threshold by the canon laid down, are represented as inherently conflicting and invalid. Finally, to illustrate the misleading character of mineralogical criteria, they push the principle *in absurdum* by proposing ironically, a division of the Azoic into twelve systems based on predominant mineral characteristics.

This memoir, though characterized by a spirit of dogmatism and wholesale contempt of contemporary research, justified only by the assumption of infallibility in the work of its authors, is still, a masterly review and a forceful argument, challenging serious reconsideration of the evidences on which many of our recent judgments have been based.

T. STERRY HUNT.

Dr. Hunt's writings on pre-Silurian rocks have been voluminous and long continued. His utterances are largely of an inferential and deductive character, based on the field-observations and judgments of others, backed, however, by numerous personal reconnoissances. He appears to have been to some extent, the expositor and commentator and public representative of the Canadian survey. The value of his work in the aggregate — especially his chemical and mineralogical work, is great. He has made a durable impression on the science of his day. But his proper geological utterances, while always learned and sagacious, have sometimes possessed doubtful value. From lack of close adherence to observations made by himself, and from too much readiness to give utterance to the intuitions of the moment, he has fallen into occasional self-inconsistencies, and many conflicts with his fellow workers in geology. Partly for such reasons, I shall not follow out in detail the varying utterances which during a long life, he has placed on record.

1855. Dr. Hunt appears to have been the first to employ the term "Huronian" in its application to a series of rocks. In "A Sketch of the Geology of Canada," speaking of the rocks on the north shore of lake Huron, then recently studied by Mr. Murray, he says:

"As these rocks underlie those of the Silurian system, and have not as yet, afforded any fossils, they may probably be referred to the Cambrian system (Lower Cambrian of Sedgwick). . . This *Huronian formation* is known for a distance of about 150 leagues upon lakes Huron and Superior."[*]

1858. Dr. Hunt suggested evidences of the contemporary existence of organic life in the limestones, graphite and iron ores of the Laurentian.[†]

On the discovery of *Eozoön* so called, he discussed the mineralogical relations of the object, and gave the name *loganite* to a supposed new mineral form.[*]

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[*] *Canada at the Universal Exposition* of 1855, pp. 427, 428. [*Esquisse géologique*, pp. 28, 33, 1855]. Mr. Murray, as we have seen, had already employed the term *Huronian series* in his report for 1855; but that was not printed till 1857. Neither he nor Hunt employed the term deliberately, as the designation of a well comprehended system of rocks, but only to express the geographical position of certain rocks referred to. In 1857, Sir William Logan made formal announcement to the American Association, that the term *Huronian* had been adopted. See *anté*, pp. 123, 124.

[†] *Quar. Jour. Geol. Soc.*, xv, 493.

In the *Esquisse géologique du Canada*,[†] Dr. Hunt described the Laurentian system as embracing two distinct series, one resting *discordantly* on the other. These he denominated Lower Laurentian and Upper Laurentian or Labradorian (afterward called by him Norian).

The so-called "Hastings series" was first brought into notice in 1852-3 by Mr. Murray (pp. 103-108), and in the discussion of these rocks, Dr. Hunt frequently participated. In *1863*, he gave analyses of the limestones (*Rep.*, 1863, pp, 592-3). In *1867*, he stated that the Hastings series reposed in *concordant stratification* on the Laurentian gneiss, but that the Upper Laurentian or Labradorian, rested *unconformably*, not only on the Lower Laurentian, but also on the Hastings series.[‡]

In *1869*, he identified as Laurentian,[§] "the great gneissic and hornblendic formation stretching through" the northeastern portion of Massachusetts, and inclosing crystalline limestones, and on the ground of their age, promoted successfully the search for *Eozoön canadense.*

In *1870*, his attention was again turned to the geology of eastern New England,[||] and he recorded the conclusion that, "In fact, the schists and gneisses of the White Mountains are clearly distinct, lithologically, from the Laurentian and the Huronian, as well as from the crystalline rocks of the Green Mountains, and from the fossiliferous Upper Silurian strata, which lie at the southwestern base of the Canadian prolongation of the latter." (p. 84.). Turning then, to the lithological characters of the "Hastings series" in Canada, he says Mr. Vennor has shown that "it rests unconformably upon the old Laurentian gneiss, while it is at the same time overlaid by the horizontal limestones of the Trenton group. This intermediate series which attains a thickness of several thousand feet, is terminated by calcareo-micaceous schists, in which *Eozoön canadense* has been found, both in Madoc and Tudor." (p. 85.) He then summarizes Mr. Murray's observations in Newfoundland in 1866 and recognizes there a mass of rocks "immediately succeeding the Laurentian," and concludes:

"From these investigations of Mr. Murray, we learn that between the Laurentian and the Quebec group, there exists a series of several thousand feet of strata, including soft, bluish-gray mica slates and micaceous limestones belonging to the Potsdam group; besides a great mass of whitish granitoid mica slates whose relation to the Potsdam is still uncertain. To the whole of these we may perhaps give the provisional name of the *Terranovan series*, in allusion to the name of Newfoundland." (p. 87.)

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[*] *Geology of Canada*, 1863, p. 490.

[†] *Paris Exhibition of 1867*, p. 10.

[‡] *Esquisse géologique* pp. 5, 6.

[§] On Laurentian rocks in eastern Massachusetts, *Am. Jour. Sci.*, II xlix, 75-78.

[||] "On the Geology of Eastern New England," *Amer. Jour. Sci.* II. l, 83-90.

The Terranovan series therefore occupies a portion of the interval in which lies also the "Norian" and the "Huronian," and it overlaps the Potsdam. To this he referred the White Mountain rocks, as well as certain rocks in New Brunswick.

In *1868*, he prepared a memoir on the mineralogy of the "Laurentian limestones of North America*" in which he wrote:

"In the county of Hastings, in the Province of Ontario, not less than 21,000 feet of strata, consisting of crystalline schists, limestone and diorite are found resting *conformably* upon Laurentian gneiss." (p. 48.)

In a postscript (p. 98,) he states:

"More recent researches by the Geological Survey of Canada have shown that the rocks of Hastings county, Ontario, noticed on page 48, rest *unconformably* upon the Laurentian, and belong to one, and possibly two, distinct systems. The upper and larger portion consists in great part, of mica schist and micaceous limestones, while at the base are great masses of dioritic and hornblendic schists, with iron ore, posssibly of Huronian age."

In *1873*, he was reported as follows:

"As regards the *Norian*, which had been once joined to the Laurentian, he had elsewhere shown that we had reason for suspecting that it might be more recent than the Huronian, and possibly than the *Montalban*, a conclusion which appeared to be confirmed by the facts made known by Hitchcock."†

In *1875*, he returned to a study of the White mountains, or Montalban series, which he had already identified with the Hastings series. He said:

"These ancient rocks are also largely represented in Hastings county, Ontario, where they occupy a position between the Laurentian [i. e. Lower Laurentian] and the fossiliferous limestones of the Trenton group, and are the equivalents of similar limestones and micaceous quartzytes in Berkshire county."‡

In *1878*, Dr. Hunt referred the limestones of the Hastings series

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***Twenty-first Annual Report of the Regents of the University of the State of New York*, Apepndix, pp. 47-98.

†*Proc. Bost. Soc. Nat. Hist.*, 1873, xv, 310.

‡*Proc. Soc, Bost. Nat. Hist.*, 1875, xvii, 509.

to the lower Taconic (Taconian).[*] In his "Chemical and Geological Essays," the Hastings limestones and slates are said to lie between the Huronian and Trenton.

In *1878*, he prepared a synopsis[†] of his views on the classification of Eozoic (Archæan, Azoic) rocks. Their divisions were distributed as follows:

1*d*. MONTALBAN. Named in 1872[=Terranovan], well displayed in the White Mountains, and occupying large areas in New England and southwestward; a great mass of crystalline schists. Gneisses distinguished from those of the Laurentian by being finer grained and having white feldspar. They are less firm and more tender, often containing silvery mica, and pass into coarser mica schists. This series contains granular olivine rocks [*dunite*] often accompanied by enstatite [*saxonite* of Wadsworth].

1*c*. HURONIAN. Named in 1855, more or less schistose, crystalline rocks, resting unconformably on the Laurentian. "The Green mountain series." Contain jaspery petrosilex, becoming porphyritic by the presence of feldspar and of quartz in a compact base, sometimes schistose and finely laminated. Contain basally, chloritic schists altered from diabases. [The description applies to the lake Superior pseudo-Huronian, not to the original lake Huron Huronian.]

1*b*. NORIAN. The upper portion of the Laurentian series on the Ottawa river. A distinct terrane, resting unconformably upon the gneisses and crystalline limestones of the Laurentian. The former Upper Laurentian or Labradorian. Consists chiefly of anorthic [triclinic] feldspar, sometimes almost without admixture; sometimes accompanied by small portions of hornblende, of pyroxene or of hypersthene (hypersthenite or hyperite). Fine or coarse. Colors white, pale bluish or greenish, dark lavender, smoke-blue or nearly black. Titaniferous iron occurs in great beds.

1*a*. LAURENTIAN. Named in 1854, prevailingly a strong, massive gneiss, reddish or grayish, sparingly micaceous, very often hornblendic. The crystalline schists absent. Crystalline limestones present, often associated with beds of quartz. Masses of magnetite. Beneath these (the *Grenville series*) a great mass of granitoid gneiss without limestone (the *Ottawa gneiss*).

Above the Montalban is placed the TACONIAN (=Lower Taconic); QUEBEC group (=Upper Taconic or Cambrian), (pp. 10, 11, 12, 13, 21).

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[*] *Proc. Bost. Soc. Nat. Hist.*, 1878, xix, 278; preface to second edition of *Chem. and Geol. Essays*, pp. xxii, xxvi.

[†] *The Geologists' Traveling Handbook*. By Dr. James Macfarlane. New York, 1879. It was circulated before the close of 1878.

The following is Dr Hunt's view of the taxonomy of the lower rocks in his Pennsylvania Report:*

8. SILURO-CAMBRIAN. Upper Cambrian of Sedgwick. Part of Lower Silurian of Murchison, and the Matinal of Rogers, in part.

7. CAMBRIAN. The Lower and Middle Cambrian of Sedgwick, and the Lower and Upper Cambrian of Hicks; being the Upper Taconic of Emmons, and the Quebec group of Logan: or the Primordial Silurian, and part of the Lower Silurian of Murchison. [Upper Copper-bearing rocks of Logan.]

6. KEWEENIAN. The Copper-bearing series of Lake Superior, found in the same geological interval as the Taconian, but not identified with it.

5. TACONIAN. The Lower Taconic of Emmons, or the "Hastings series," including a part of the Primal, Auroral and Matinal divisions of Rogers; and constituting with the Montalban, what he had once called Terranovan.

4. MONTALBAN. The White Mountain or Mica schist series. [Terranovan in part.]

3. HURONIAN. The Green Mountain series, or altered Quebec group of Logan. [Lower Copper-bearing rocks of Logan.]

2. NORIAN. The Labradorian or Upper Laurentian of Logan.

1. LAURENTIAN.
   - b. *Grenville series.* With limestones. Supposed unconformable with the next.
   - a. *Ottawa gneiss.* Without limestones. (pp. 215-242.)

In *1879*, the Norian was said by Dr. Hunt to rest *unconformably* upon the gneisses and crystalline limestones of the Laurentian, and held to be older than the Huronian. The Huronian was also said to rest *unconformably* on the Laurentian on the north shores of lakes Huron and Superior.

In *1886*,† Dr. Hunt's conception of the succession of the Azoic Rocks was freshly set forth with a result of which a brief abstract is as follows:

SILURIAN.
ORDOVICIAN.
CAMBRIAN.
KEWEENIAN. Upper division of Upper Copper-bearing series.

**Special Report on the Trap Dykes and Azoic Rocks of southeastern Pennsylvania.* By T. Sterry Hunt. Part I. Historical Introduction. Harrisburg, 1878 pp. 253. [Being E of the series of Survey Reports. This Report is dated 1875, though the Preface bears date 1878.]

†*Mineral Physiology and Physiography*, a second series of Chemical and Geological Essays, with a General Introduction. Boston, 1886, 8vo, pp. xvii plus 710.

TACONIAN. Lower division of Upper Copper-bearing series. Quebec group of Logan.

MONTALBAN.

HURONIAN. ?*Pebidian* of Hicks.

ARVONIAN. (Formerly part of Huronian.) Petrosilex series,—jaspers and porphyry. *Hälleflinta*, Sweden. *Arvonian* of Hicks.

NORIAN. (Formerly Upper Laurentian or Labradorian.)

LAURENTIAN. (Former Lower Laurentian.) ?*Lewisian* of Murch.

Grenville series. Typical Laurentian (Former Middle Laurentian.) *Dimetian* of Hicks.

Ottawa gneiss.[*]

Dr. Hunt has always been resolutely opposed to the identification of the Animike Series with the proper Huronian. The following passage, among many others is explicit:

"The fact that the Taconian or Animike series in Northern Michigan, rests sometimes upon the Granitoid or Gneissic group, sometimes upon the Dioritic group, of Rominger, and elsewhere upon a mica schist series having the characters of the Montalban, goes far to show its stratigraphical distinctness from all three of these. Its separation from the Dioritic group was early noticed by Logan, when he described the unconformable superposition of this series (the lower division of his Upper Copper-bearing series) on the ancient greenstone (Huronian) series, and the presence of portions of this in the basal conglomerates of the latter. There are, however, as I have elsewhere noticed (*Azoic Rocks*, p. 202,) certain mineralogical resemblances between the Taconian and the softer and more schistose beds of the Huronian, with which they were confounded by Murray at more than one locality along the north shore of Lake Superior. Hence, after visiting the Marquette district in 1861, he did not hesitate to call the iron-bearing series of that region Huronian; a designation adopted by the Geological Survey of Canada. In this he was followed by J. P. Kimball in his study of the Marquette iron ores in 1865, by Hermann Credner in 1869, by T. B. Brooks in 1873 and again by Irving in 1883. All of these include the two series under the common name of Huronian, and the estimates of the thickness of the Huronian have been based upon that of the two united. The distinctness of the underlying Dioritic group with its serpentines and chloritic rocks, which together constitute the Huronian or *pietre verdi*—alike from the older granitoid and gneissic group, from the mica-schist or Montalban group and from the great overlying Animike or Taconian system, including the quartzites, marbles, iron-ores and argillites, is however, manifest. The succession is thus brought into complete accordance with that which is found in many parts of the Appalachians, as well as in southern Europe, as is pointed out in part iv of Essay X."[*]

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[*] The following references may be made to opinions of Dr. Hunt on the geology of New Brunswick: Hunt: *Geology of Canada*, 1866, pp. 235, 236; *Amer. Jour. Sci.*, II, 1870, 1, p 39 (Compare *Proc. Amer. Assoc.*, 1871, p. 33;) *Azoic rocks*, 1878, 181, 188, 189; *Proc. Amer Assoc.*, 1873, B, 116, 117; 1879, 285-7; *Amer. Jour. Sci.*, 1880, III., xix, 273-5; *Boston Proc.*, 1875 xvii, 509; *id.*, xix, 278; Preface, 2d. ed. *Chemical and Geological Essays*, p. xxix; *Mineral. Physiology and Physiography*, pp. 407-8, 572-4.

Dr. Hunt, in other passages, recognizes the presence of the Animike (Taconian) or true Huronian in the Upper Peninsula of Michigan. He writes:

"Resting in some cases upon this group[†] and in others upon the granitoid rocks is a great system divided in ascending order by Rominger, in 1880, into a Quartzite group (which includes a marble series,) an Iron-ore group, and an Arenaceous-slate group, all of which appear closely connected. The system comprises heavy beds of quartzite, often schistose and with conglomerates, interstratified and overlaid by argillites of various colors, with graphitic, hydro-micaceous or sericitic slates, beds of jasper, of hæmatite and magnetite, either pure or disseminated, and, in the upper portion, limonite and siderite. The limestones form in the upper part of the quartzite division, great masses of white crystalline marble, sometimes with mica and tremolite and sahlite; at other times they are reddish or dull and compact. The iron ores appear to be in two horizons, one below and one above a great body of limestone. To the latter are referred the ores of the Gogebic and Menominee districts, and to the former, those of Marquette and Felch mountain, with which those of Vermilion lake in Minnesota, appear to be identical. The argillites which overlie the latter are those seen in the St. Louis river and at Thompson, Minnesota, which are by Rominger compared with argillites at L'Anse and Huron bay."[‡]

George F. Matthew and Associates in New Brunswick.

Several different Canadian geologists have participated in the investigation of the geology of the maritime provinces of British North America. The pioneer among them was the present Sir William Dawson, whose special studies for the greater part, have

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[*] *Mineral Physiology*, 581-2.

[†] The Dioritic group of Rominger.

[‡] *Mineral Physiology*, pp. 579-80. The writer has elsewhere recorded his independent recognition of the existence of two discordant systems in the Marquette Iron region—*Sixteenth Annu. Rep. Minn.*, pp. 178-9, 185.

of New Brunswick.

Bailey & Matthew, '77-78.	Bailey, 1880.	Bailey, Matthew & Ells, 1878-9.
Kingston series.*13*	Certain feldspar porphyries.	Silurian. Cambro-Silurian. Cambrian or Primordial.
Cambrian or Primordial, or St. John gr.	Upper Kingston gr.	
chistose, chloritic and micaceous gr., coastal gr. Felsite-petrosilex (Coldbrook).	Lower Kingston. Coastal gr. Talc schists, congl. limestone. Coldbrook gr. Felsitic.*14* etc.	Kingston Division: *16.* Felsite, schist, slate cong., felsite cong. and clay slate. Coastal Division: Chloritic, felspathic and talcose; schistose cong. Coldbrook Division: Petrosilex and felsite, agglomerates, diorites, etc.
Lime-stones and dolomites, mica schists. yenitic, feldspathic and gneissic.	Finer gneiss, quartzites = ?Hastings. Coarse gneiss.*15*	Syenite and gneiss, quartzite, felsite, limestone, mica and felsite schists. Syenite-gneiss and felsite.

Lower Devonian, but, from its lithological characters placed in the Huronian.]
Silurian strata; but Coastal overlies them.
rred to the Upper Silurian in Rep. of 1874-5, pp. 84-9.
n the St. John group.
ogical evidence.
not unfrequently, evidence of at least a partial unconformability."
nitic axis, numerous blocks, or what appear to have been detached masses of gneiss
nded by, or included in, the granite in such a way as to look like a coarse con-
. p. 420.
ed with the Animike of Lake Superior.

been palæontological.[*] Among those who have contributed important original observations and have studied especially the oldest rocks, are George F. Matthew, L. W. Bailey and R. W. Ells. This portion of the continent presents great geological difficulties, and the interpretations of the phenomena have been very diverse. The differences, however, have been rather of local than of geognostic significance; and it is therefore not intended to trace the historical development of opinion into detail. Following Sir William Dawson, Mr. George F. Matthew, in 1863, presented the results of a well elaborated series of observations on the geology of St. John county, New Brunswick[†] and proposed an arrangement of the rocks which will be reproduced synoptically in the following table.[‡]

The table which follows is compiled from papers cited in this connection.

CHARLES H. HITCHCOCK.

Professor C. H. Hitchcock's survey in the state of Maine did not lead him into researches possessing any important bearing on the development of American opinion respecting the nature and origin of the older rocks. The official character of his connection with the Vermont survey, the first volume of the final report of which was published in 1861, though prepared in 1859, was as chemist of the survey. But, provision for the chemical work being inadequate, professor Hitchcock devoted much attention to geological investigations. Among these was the preparation of a chapter on "Azoic Rocks" and contributions on "Steatite and Serpentine" and "Saccharoid Azoic Limestone."[§]

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[*] *Acadian Geology. The Geological Structure, Organic Remains and Mineral Resources of Nova Scotia, New Brunswick and Prince Edward's Island.* First edition, 1855, 2d, 1868 (with information posted to date), 3d, 1878. For other recorded opinions of Sir William Dawson, see *Can. Nat. and Geol.*, 1861, I, vi, 164; *Quar. Jour. Geol. Soc.*, 1862, xviii, 303. Sir W. E. Logan made a reconnoissance of the Bonaventure formation in 1843; and Dr. Abraham Gesner made a report to the New Brunswick government at nearly the same date.

[†] *Canadian Naturalist and Geologist*, viii, 241-260, Aug. 1863. For later views see *Quar. Jour. Geol. Soc.*, 1865, xxi, 422-434.

[‡] The later studies of Messrs. Matthew, Bailey, Hartt, Ells and others may be consulted as follows: Bailey: *Canadian Naturalist*, 1864, 81-97 (a rapid reconnoissance); Bailey, Matthew and Hartt: *Observations on the Geology of Southern New Brunswick*, 1865: H. Y. Hind: *Prelim. Report on the Geol. of New Brunswick*, 1865; Bailey and Matthew: *Proc. Amer. Assoc.*, 1864, xviii, 179-195 (revised to April, 1870); Bailey and Matthew: *Geol. of Can. Report of Progress*, 1870-71, 13-240 (proposing numerous changes on recommendation of Dr. Hunt); Matthew: *Report*, 1874-5, pp. 84-9; *Report* for 1876-7, 322-350; Hugh Fletcher: *Same Report*, 405-426; R. W. Ells: *Rep. Prog.* for 1877-8, D., pp. 1-12; L. W. Bailey: *Rep.* 1877-8, DD., pp. 1-34; G. F. Matthew: *Same Rep.*, E, pp. 1-6; Bailey, Matthew and Ells: *Rep.*, 1878-9, D., pp. 1-26; R. W Ells: *Rep.*, 1879-80, D., pp. 30-42; *Rep.*, 1880-82, D., pp. 17-19: Bailey: *Proc. Amer. Assoc.*, 1880, 416, 417: *Can. Rep.*, 1882-4, E., pp. 31-34; A. P. Low: *Rep.*, 1882-4, F., pp. 16-20; R. W. Ells: *Rep.*, 1885, E. pp. 54-63. Dr. T. S. Hunt's recorded opinions have been already referred to, *Ante*. p. 150

[§] *Geology of Vermont*, I, pp. 452-474 and 533-558.

In consonance with views generally prevailing at the time, he expresses the opinion respecting the azoic rocks, that "stratification and lamination appear to have been produced by original deposition in water." Speaking of the difficulty of distinguishing, in some cases, between the lines of sedimentary structure and cleavage and foliation, he says: "We have not attempted it [distinction of cleavage] to much extent in the slates of Vermont; still less have we tried to draw a line of distinction between the foliation of the schists and stratification; for this is a still more difficult work. Hence the strikes and dips which we shall give are those of foliation and cleavage. But we believe that these usually correspond essentially with the stratification. In the fossiliferous clay-slates of the western part of the State, as well as in the limestones, we not unfrequently have found the cleavage planes making quite an angle with those of the original deposition; but in all those belts of slate interstratified with the more thoroughly metamorphosed schists, the two seem usually coincident." (p. 452.)

No attempt is made to give the azoic rocks either a systemic, a geognostic or a chronological arrangement. Fifteen species are enumerated and lithologically described. Five and a half quarto pages are devoted to a catalogue of isolated instances of strike and dip, though very little attempt is made to correlate them in a general system of structure. It is stated however, that three distinguishable ranges of gneiss traverse the state: the Green mountain range, the middle range and the Connecticut river range. The first of these is thought a continuation of the Hoosac mountain range—the gneiss of the Green mountains resulting from the accession of feldspar to the mica schist of Massachusetts, though often, in Vermont, passing again into mica schist. Of some of the gneiss of the range along the Winooski, he says "it resembles sandstone—the crystals of feldspar being rounded like large grains of sand. (p. 465.) The middle range is less extensive and more distinctly gneissic. Eastward it graduates into mica schist. The gneissic range near the Connecticut river consists only of three patches."

The unessential character of the recognized distinction between gneiss and mica schist, as indicated in the transitions along the strike, mentioned above, is emphasized by further statements. "Those layers of the rocks" he says, "on both sides of the mountain, which all would regard as gneiss, are generally interstratified with other layers of mica or talcose schist and quartz; and the judgment of good observers would differ about the line where the gneiss predominates over the schists." "Also, as we pass northerly along the line of strike [of the Green mountain range] along the eastern margin, the gneiss is rapidly succeeded by mica and talcose schists..** We incline to the opinion, however, that a narrow belt of Green mountain gneiss does extend across the whole State of Vermont.** We have expressed the opinion in another place, that gneiss, mica and talcose schist, and even some beds of quartz, may be only metamorphic varieties of the same original formation." (p. 470.)

Of hornblende rock he says: "It is found associated with gneiss and clay-slate in positions much like dikes, as well as in regular beds." Referring to the opinion expressed by MacCulloch, that hornblende rock and hornblende schist may result from the metamorphism of clay-slate, professor Hitchcock states that Bischof has shown it possible that "even in lava, the hornblende [sometimes present] was not formed at the time of the protrusion of the lava, but subsequently in the wet way; and the associations of hornblende schist forbid the idea that it was a volcanic product."

In reference to steatite and serpentine, professor Hitchcock states that "there are at least sixty beds of steatite in Vermont, and twenty-five beds of serpentine. The aggregate of serpentine is more than double that of steatite. Regarding the steatite and serpentine rocks as of one age in each range, he concludes that there are four ranges, and that these are of different ages.

As to origin, he regards serpentine as originally stratified, referring to its conformability with the foliation of the rocks which embrace it. There is no protruded serpentine in Vermont. Steatite, probably, had a similar origin. He believes in the change of "some beds of hornblende schist and diorite or greenstone, into serpentine." (p. 554.)

In general connection with the subject of metamorphism, professor Hitchcock makes the following just remarks:

"The distinction between stratified and unstratified rocks has been usually regarded as one of the most trenchant and reliable in the science of geology. And so long as it was considered a certain fact that the stratified rocks were exclusively deposited by water, and the unstratified all resulted by dry heat, it is not strange that geologists should have looked upon the line between the two classes as very distinct and recognizable. But now that it is so generally admitted that hot water has been the most efficient agent in metamorphosing the stratified rocks, and converting some of them into the unstratified, we can see how the distinction between them should often be very obscure and uncertain. Such is certainly the case with serpentine and dolomite, both of which are sometimes stratified and sometimes unstratified. We are apprehensive that some other system of classification must be adopted, to include such rock and also such varieties of gneiss, and even some of the schists." (pp. 554-5.)

The results of the studies of professor Hitchcock and his collaborators in the geology of New Hampshire are embraced in three massive royal octavo volumes.* They embody a vast amount of faithfully elaborated information in a region of extreme difficulty, which had hitherto received vastly less geological than mineralogical study. The state presented extraordinary difficulties, arising, *first*, from the absence of organic remains, those time-marks by which the geologist is able to recognize his position in the progress of æons past, and *secondly*, from the destruction of the traces of superposition by those orogenic disturbances which almost wholly obliterated the records originally made; and *finally*, by the metamorphism which had not only transformed the aspects and constitution of rock-masses, but had effected alterations of such varying nature and degree as to defy identification by the usual resemblances. In this trackless geological wilderness the geologist entered, meagrely equipped for his great work, and reported to the state and to the world the progress made from year to year, until lapse of time and exhaustion of means rendered it imperative to pronounce final verdicts. As a matter of obvious necessity, the geological conception underwent revision and augmentation with every season's addition of knowledge. But it was a peculiar merit of professor Hitchcock's advancing work that he was ever ready to announce the shape which his conception of the State's geological structure and history had attained after the latest acquisitions of observed fact. A less unsuspicious mind—perhaps it might be said, a more judicious method, would have enforced more reserve. The difference would be that a more prudent investigator would have reached thoughts not more mature and final, but would have held his "best thoughts" in reserve; while Hitchcock freely shared them with the public. It has been found possible to cast censure on professor Hitchcock that his annual announcements of status reached were so conflicting and changeful; but a just and generous view must regard them simply as marks of the progress of ideas, and encouragments to all who may be grappling with equal difficulties.

***Geology of New Hampshire.* By C. H. Hitchcock, J. H. Huntington, Warren Upham and G. W. Hawes, Volume I, containing Part I, (1874) "Physical Geography," 668pp; Volume II, (1877,) containing Part II, "Stratigraphical Geology," 685pp; Volume III, (1878), containing Part III, "Surface Geology," Part IV, "Mineralogy and Lithology," Part V. "Economic Geology."

It occurs to the writer that it may be best to present first, the series of provisional conclusions announced by professor Hitchcock in the progress of his work. These are taken substantially as compiled by Whitney and Wadsworth—the order of arrangement being inverted, in conformity with the method of this memoir.*

ANNUAL REPORTS. 1860-1872.

First Annual Report, 1869.

- Upper Schists.
- Quebec Group.
  - Auriferous Conglomerate.
  - Clay Slate.
  - Copper Belt.
  - Lower (mostly green) Schists.
  - Staurolite Schists.
- White Mountain series (Gneissic, Granitic)

2d Annual Report, 1870.

- Clay Slates.
- Calciferous Mica Schist.
- Coös Group.
- Lower Silurian.
  - Quebec Group.
  - Merrimac Group.
- Common Granite.
- Porphyritic Granite.
- Laurentian (?) Exeter Syenites.
- Eozoic (White Mountain or Gneissic Series).
  - Soapstones.
  - Limestones.
  - Quartzyte.
  - Porphyritic Granite.
  - Syenite.
  - Granite.
  - Chiastolite Slates.
  - Andalusite Gneiss.
  - Feldspathic Mica Schist.
  - Granitic Gneiss.
  - Ferruginous Gneiss.
  - Normal Gneiss.

3d Annual Report 1871.

- Coös Group.
- Clay Slate and Quartzytes.
- Laurentian (?).
  - Norian.
  - Brecciated Granite.
  - Trachytic Granite.
  - Common Granite.
  - Andalusite Gneiss (White Mountain Gneiss),
  - Gneiss.
  - Bethlehem Gneiss.
  - Porphyritic Gneiss.

4th Annual Report, 1872.

Division 3.

- Andalusite Slates of the Coös Group.
- Mica Schist.
- Quartzyte.
- White Mountain Series.
  - Andalusite Gneiss, Ordinary and Imperfect Gneiss, the Concord and Fitzwilliam Granite, Soapstone and Limestone.
- Granite Gneiss.
- Laurentian.
  - Granite and Porphyritic Gneiss.

Division 2.

- Norian (Pemigewasset Basin).
  - Green Granite and Syenite.
  - Four Series of Compact Feldspar.
  - Spotted Granite.
  - Common Granite.
- Laurentian.
  - Franconia Breccia.
  - White Mountain or Andalusite Gneiss.
  - Bethlehem and Berlin Gneiss.
  - Porphyritic Gneiss and Granite.

Division 1.

- Helderberg.
- Cambrian.
  - Coös Group.
    - Decomposing Slates, Dikes.
    - Calciferous Mica Schist.
    - Mica and Argillaceous Schists.
    - Quartzytes, Staurolite Schists.
  - Auriferous Clay Slates.
- Huronian.
  - Conglomerates and Quartzytes.
  - Hydromica and Talcose Schist.

PROC. AMER. ASSOC. ADV. OF SCI., 1872. xxi, 134, 135, 150.

- II. Palæozoic.
  - Clay Slates.
  - Helderberg Limestones.
- I. Eozoic.
  - 5. Older Cambrian.
    - Merrimac Group and probably Calciferous Mica Schist of the Vermont survey.
    - Coös Group.
  - 4. Huronian.
    - The Talcose Schist Series.
  - 3. Exeter Syenites.
  - 2. Norian.
    - *f.* Red compact and Crystalline Orthoclase Felsite.
    - *e.* Dark compact Orthoclase Felsite.

Bull. Mus. Comp. Zool., Vol. vii., p. 396.

  - *d.* Compact Labradorite Felsite.
  - *c.* Ossipyte.
  - *b.* Trachytic Granite.
  - *a.* Common Granite.
- 1. Laurentian.
  - *f.* Range of Gneiss between Whitefield and Milan, considerably Hornblendic.
  - *e.* Gneiss on both flanks of the Porphyritic variety in the south part of the State, carrying the Concord and Fitzwilliam Granite, and is probably the Beryl-bearing Series.
  - *d.* Gneiss of Lake Winnipiseogee Basin.
  - *c.* Bethlehem or Talcose Gneiss.
  - *b.* White Mountain Series or Andalusite Gneiss.
  - *a.* Porphyritic Gneiss.

PROC. BOSTON SOC. NAT. HIST., 1873. xv, 304-309.

- V. Palæozoic.
  - *B.* Clay Slates.
  - *A.* Helderberg Limestone.
- IV. Mostly Cambrian (?).
  - *F.* Mount Mote Conglomerates.
  - *E.* Green Granite.
  - *D.* Clay Slates.
  - *C.* Coös Group.
  - *B.* Merrimac Group.
  - *A.* Mica Schists of Rockingham County.
- III. Huronian.
  - Feldspar and Talc.
  - Whitish Schists.
  - Green Schists.
  - Talcose and Auriferous Conglomerates.
- II. Laurentian.
  - *H.* Syenites of Exeter and Tripyramid.
  - *G.* Reddish compact Orthoclase.
  - *F.* Red compact Orthoclase.
  - *E.* Dark compact Orthoclase.
  - *D.* Dark compact Labradorite.
  - *C.* Ossipyte.
  - *B.* Spotted Granite.
  - *A.* Common Granite of the White Mountains.
- I. Laurentian (?).
  - *C.* White Mountain or Andalusite Gneiss.
  - *B.* Bethlehem Gneiss.
  - *A.* Porphyritic Gneiss.

PROC. AMER. ASSOC. ADV. SCI., 1873. xxii, 120-131.

Winnipiseogee Lake.

- Eozoic.
  - Mica Schist.
  - Eruptive Syenite.
  - Labradorian.
    - Felsites or Compact Feldspars.
    - Eruptive Granites of the Ossip Mountains.
  - Laurentian (?).
    - White Mountain Series.
    - Winnipiseogee Lake Gneiss Form tion.
    - Porphyritic Gneiss or Granite.

GEOLOGY OF NEW HAMPSHIRE, 1874 i. 506-539.

- Helderberg Period.
- Mica Schist Period.
  - Coös Group.
  - Cambrian Auriferous Clay Slates.
  - Merrimac Group.
  - Rockingham Mica Schist.
- Eozoic.
  - Huronian.
    - Conglomerate.
    - Serpentine with Silicious Schist and Dolomite and Soapstone.
    - Copper and Iron Beds.
  - Labrador.
    - Eruptive Syenite.
    - Fine Sedimentary Deposits.
    - Chocorua Granite.
    - Albany Granite.
    - Conway Granite.
  - Atlantic.
    - Franconia Breccia Group.
    - Montalban.
    - Lake Gneiss.
    - Bethlehem.
  - Laurentian.
    - Porphyritic Gneiss.

WALLING'S ATLAS OF NEW HAMPSHIRE, 1877.

- Palæozoic.
  - Silurian.
    - Slates, Conglomerates, etc.
    - Helderberg Limestones.
  - Cambrian.
    - Mt. Mote Conglomerate.
    - Clay Slates.
    - Coös Group.
    - Calciferous Mica Schists.
    - Rockingham Schists.
  - Huronian.
    - Auriferous Conglomerate.
    - Lyman Group.
    - Lisbon Group.
  - Labrador or Pemigewasset.
    - Exeter Syenites.
    - Compact Feldspar.
    - Ossipyte.
    - Chocorua Granite.
    - Albany Granite.
    - Conway Granite.
  - Atlantic.
    - Franconia Breccia.
    - Montalban or White Mountain Series.
    - Lake Winnipiseogee Gneiss.

    - Bethlehem Gneiss.
- Laurentian.
    - Porphyritic Gneiss.

GEOLOGY OF NEW HAMPSHIRE, 1877.
II, 674, 675.

I. Stratified Groups.

- Palæozoic.
    - Lower Helderberg.
    - Calciferous Mica Schist.
    - Coös Group.
        - Staurolite Slate.
        - Mica Schist.
        - Quartzyte.
    - Cambrian Slates.
- Palæozoic (?).
    - Kearsarge Andalusite Group.
    - Rockingham Mica Schist.
    - Merrimac Group.
    - Ferruginous Slates.
- Eozoic.
    - Upper Huronian.
        - Auriferous Conglomerate.
        - Lyman Group.
        - Lisbon Group.
        - Swift Water Series.
        - Hornblende Schist.
    - Lower Huronian.
    - Labrador.
    - Montalban.
        - Franconia Breccia.
        - Fibrolite Schists.
        - Ferruginous Schists.
        - Concord Granite.
        - Gneiss and Feldspathic Mica Schists.
- Laurentian.
    - Lake Winnipiseogee Gneiss.
    - Bethlehem Fine-grained Gneiss.
    - Bethlehem Ordinary Gneiss.
    - Porphyritic Gneiss.

II. Eruptive Masses.

- Augitic.
    - Diabase.
    - Diorite.
- Feldspathic.
    - Trachyte.
    - Pequawket Breccia.
    - Porphyry.
    - Labradorite Diorite.
- Granitic.
    - Exeter Syenite and Diorite.
    - Syenite of Mt. Gunstock, &c.
    - Granite not otherwise Assigned.
    - Granite cutting Coös Group.
    - Chocorua Series.
    - Albany Granite.
    - Conway Granite.

In a region where palæontological aids to investigation are wanting, the geologist must rely on indications of superposition, physical conformities, characteristic minerals and petrographic resemblances. The application of the petrographic criterion is involved in distracting difficulties by the progressive and unequally-paced changes which crystalline aggregations have undergone in the presence of the dynamic agents of geology. Hence the greater necessity for seeking always the evidences from superposition. Professor Hitchcock, with a true evaluation of the only expedients available, enunciated in 1873, the fundamental principles by which he was guided:

"Logan, in 1855," he says, "described a system of rocks overlying unconformably the Laurentian gneisses about Lake Huron, which were distinguished by means of lithological characters. All geologists, therefore, who use the name Huronian, of necessity practically adopt this principle, though perhaps insensibly. We do not claim that a talcose rock can never be found in any other system than the Huronian, nor that gneiss may never be stratified with the hydromicas. Professor Dana's recent paper shows that gneisses, quartzites and limestones are interstratified in the Silurian of western New England.* In no instance would we claim that mineral character is sufficient to distinguish systems without a study of the relations of the strata. We may sometimes generalize, and believe that rocks of similar mineral characters must be of the same age, but such speculations must always provide for confirmation by a study of the strata."[*]

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*Proc. Amer. Assoc., 1873, Sec. B, p. 147.

An application of the mineralogical criterion is seen in what, in the report for 1870, is called "porphyritic gneiss."

"There are over Thirty areas of porphyritic gneiss in which the feldspar crystals are very conspicuous for their size, the rock being the *Augen-gneiss* of Europe. I assume that all the areas of this rock are identical in age, and in speculating upon the relative positions of the intervening groups, rely upon the correctness of this starting-point.* * The fact of minor differences would seem to confirm our assumption of their identity in age, just as the palæontologist finds, from the presence of the same fossils, proof of contemporaneity in the rocks with dissimilar mineral character. From these facts it is inferred that the porphyritic gneiss is older than the Lake or the Montalban gneisses, the last being the newest.* * It may as well be said now as at any time, that nothing older than the porphyritic gneiss has yet been discovered. This formation constituted the first dry land in the State."[†]

Professor Hitchcock's changes of opinion are illustrated in his record in reference to the Norian. This division, following Hunt, was first introduced into the report for 1871. Of its relative position he says:

"All will agree that the mineral labradorite belongs to the original Laurentian system; and therefore, by its discovery in New Hampshire, will be satisfied that some of our crystalline rocks belong to the older series of the Eozoic, and not the Palæozoic. Hence the prevalent opinion respecting the age of the New England metamorphic rocks must be changed to conform with the discovery of labradorite in our state.* * Our conclusions as to the absolute and relative ages of the New Hampshire formations depend upon the reference of some of them to the Norian system of Hunt."[‡]

Professor Hitchcock, therefore, in establishing the high geological antiquity of the White mountains, had a long-strengthening sentiment to combat. It was recognized however as Norian by Hunt, in 1873.[*]

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[*] *Pro. Amer. Assoc.*, 1873, Sec. B. p. 147.

[†] *Final Report* vol. ii. pp. 659, 660, 663, 664.

[‡] *Report.* 1871. pp. 4-10. The allusion made in the above paragraph may be illustrated by the following citations: "To the Chemung and Portage group of New York* * may perhaps be referred, in part, the rocks of the White Mountains (Hunt, *Amer. Jour. Sci.* 1850. II. ix. p. 19; *Proc. Amer. Assoc.* 1849, II. pp. 333,334.) "It is moreover probable that the rocks of New Hampshire, including the White Mountains, are altered strata of Devonian age." (Hunt, *Geol. of Canada*, 1863. p. 508.) The same opinion was reiterated in 1867 (*Esquisse géologique du Canada*, p. 23; *Bull. Soc. géologique de France*, 1867, II, xxiv. p. 687.) In 1860, professor J. P. Lesley expressed the opinion that the range of the White Mountains would prove to be synclinal instead of anticlinal, and therefore of probable Devonian age. (*Proc. Acad. Nat. Sci. Phil.*, 1860. xii, pp. 363-364.) Logan, also, accord-

In 1872, Hitchcock more formally defended the supposed sedimentary character of these rocks:

"It is a perplexing matter to determine the lines of stratification, as the outcrops are divided by two prominent sets of jointed planes, either of which might be called layers of deposition, the rock being essentially homogeneous. One set dip 20° northerly, and are the most numerous, The other dip about 75° W10°S."[†]

In the Report for 1872, published later than this, he adds:

"As the latter [joints] correspond better in position with the supposed strata of nodular gneiss, it was thought they indicated the proper lines of deposition."[‡]

These beliefs were iterated in 1872. Referring to the same locality and the same terrane, he says:

"The rock seems to be stratified, its planes dipping about 20° northerly * * The importance of this discovery may be best appreciated by remembering that the presence of the lime feldspars affords a strong presumption that the rocks are Eozoic, and not metamorphic Palæozoic formations. It seems to be generally admitted by geologists that the feldspars are confined to the older rocks, except as found in eruptive trappean and volcanic masses."[§]

In the second volume of the Final Report, he adheres to the same opinions:

"I was at first satisfied that this rock was gneiss, but did not recognize its true place in the porphyritic group. Subsequently I referred it to the "trachytic" or Albany granite, but a re-examination in 1875, shows that it belongs to the oldest of our formations, and is distinctly stratified, traversed by trap dykes, and narrow banded veins of quartz * * The labradorite rocks with a very moderate dip, rest unconformably upon the greatly upturned edges of the Montalban schists, as if there had been large upheavals at the close of the Montalban period, and comparatively little disturbance since. * * The facts as interpreted, are of great consequence, since they fix the geological horizon of the whole

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ing to Hunt, regarded them as probably "altered Devonian strata" (*Azoic Rocks* pp. 86, 87, 182.) (See also *Amer. Jour. Sci.*, II, ix, 19, 1849; II, xxxi. 403, 1831.) In 1870, Hunt pronounced the White mountains Terranovan. *Amer. Jour. Sci.*, II. l. 83-90, 1870. The various older opinions are reviewed at length by Hitchcock in Final Report, ii, 184, 198, 264-7.

[*] *Proc. Boston Soc. Nat. Hist.* xv, p. 310, 1873.

[†] "The Norian Rocks of New Hampshire," *Amer. Jour. Sci.* III, iii, 43-47, 1872.

[‡] *Ann. Rep. 1872.*, pp. 15, 16.

[§] *Proc. Amer. Assoc.*, *1872.*, xxi, pp. 135-151.

Atlantic system, while considerations of a stratigraphical character confirm this impression. * * The discovery of the Labrador system, overlying the most abundant and characteristic White Mountain strata, makes it clear that the latter are older than the former, which are confessedly Eozoic."[*]

In spite of this oft repeated conviction of the sedimentary nature of these labradorite rocks, and of their occurrence in seven different areas among the White mountains, we find professor Hitchcock on a later page of the same volume, employing the following language:

"The Labrador system, if present in New Hampshire, is in very limited amount. Recent investigations make it difficult to say that the labradorite rocks are not of eruptive character. They have the composition of dolerite; and certain exposures of them upon Mount Washington are surely injected dykes. Hence great doubt arises whether the larger area of Waterville really represents the Labrador system of Canada. At all events, its age is great, for these dykes cut through the Montalban strata [He had very recently said the labradorite rocks rest discordantly on the upturned edges of the Montalban]. This dolerite may be regarded as one of the oldest eruptive rocks in the State, coming to the surface in what was the labrador age of the world."[†]

The eruptive nature of this mass was detected by Dr. Hawes; and is recorded in the third volume of the New Hampshire report, dated 1878, though it does not appear at what date Part iii was printed, nor at what earlier date it was prepared. He says:

"Gabbro is found in immense masses in Waterville and in the vicinity of Mount Washington. The relationships of its masses to the surrounding strata are not so easily determined as those of the little dikes of diabase and diorite, the walls of which are usually plainly seen; but at some points the rock possesses all the structure of an eruptive mass and when, in other places, this is not found, the evidence furnished by more favorable localities, as well as that furnished by allied rocks in other lands where they have been more thoroughly investigated, must at present be decisive."[‡]

Dr. Hunt now found occasion to change his position:

"The labradorite rocks in the White Mountains, which had by Hitchcock been referred to norite, are now found by him to be eruptive masses."[§]

The "porphyritic gneiss" always commanded the attention of professor Hitchcock. He early published observations as follows:

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[*] *Final Report* II. pp. 214,258,266.

[*] *Final Report*, II, p. 667.

[‡] *Final Report New Hampshire*, III, p. 165.

[§] *Azoic Rocks*, p. 161.

"The sections given of the common granite, trachytic granite and the Norian series (or at least certain felsites) seem to determine their relative positions, the last being at the top. The brecciated granites of Franconia seem to be older than any of these and to underlie them. * * If these points are assumed, the porphyritic gneiss can be shown to be at the bottom of the series, for it lies outside of the lowest of them."*

In the next annual report the "porphyritic group is described as consisting "mainly of gneiss full of large crystals of orthoclase feldspar, associated with ferruginous and other bands. It is regarded as the oldest of all the formations in the State," for reasons which are enumerated."†

The position of this gneiss is again referred to:

"If the felsite series is of the age of the Upper Laurentian or Labrador of Logan, then by the law of superposition, the strata underneath the common granite are Lower Laurentian. Observation showed us, at this phase in the development of the White Mountain structure, two gneisses and a breccia underneath the granitic sheet. The most important is the "Porphyritic gneiss," or granite sometimes. This is a gneiss having large crystals, usually one and a half inches long, of orthoclase, arranged in layers in the mass, with the longer axes parallel to each other. These we conceive to be the strata.* *

"The descriptions of the Laurentian rocks in Canada and Europe make mention of large quantities of porphyritic gneiss; hence we feel warranted in referring these lower schists to the Laurentian system. We have found nothing older in the state." ‡

Again, in a later discussion of the parallelism of the groups recognized in New Hampshire, having mentioned the Canadian systems, Laurentian, Labrador, Huronian and Cambrian, he says:

"The first two of our groups may be referred to the oldest of these, the Laurentian, without hesitation. We do not possess exhaustive information about the occurrence of this oldest system in other regions. So far as is understood, there are two sorts of associated rocks in its typical localities, one being largely pyroxenic. That variety is wanting in New Hampshire. A porphyritic or *Augen-gneiss* is eminently characteristic of the fundamental rocks in every part of the world; and hence ours may readily be called Laurentian. * * [After correlating succeeding New Hampshire

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***Annual Report*, 1871, pp. 25-27.

†*Annual Report*, 1872, p 11.

‡*Proc. Amer. Assoc.*, 1872, xxi, pp. 145-6.

groups, he continues.] The Montalban series are certainly not characteristic of the Laurentian. * * Dr. Hunt is satisfied that they overlie the Huronian or greenstones. Our own observations lead to the view that the typical Montalban rocks underlie the same, as recently stated, though the precise relationship is not beyond controversy."[*]

I make but two citations further bearing on the structural character and taxonomic disposition of New Hampshire Archæan rocks. The first is connected with the genesis of certain systems :

"If these granites behave like a stratified formation, of course the question is at once raised whether they should not be regarded as true strata. The answer cannot be given from position merely, since it is not uncommon to find sheets of trap or lava holding a perfectly analogous position. We have preferred to think of the White Mountain country, at the end of the Laurentian period, as an immense basin, upon which there was an overflow of common granite. Being liquid it spread itself out like water, assuming a horizontal surface. After a while, there was an eruption of trachytic granite, which spread itself in the same way. Subsequently the felsites were formed above them conformably. It would be natural to regard these granites and felsites as belonging to one period, the Norian. The limits of this system have not been fixed; and it seems as if in New Hampshire, it should commence in the common granite and end with the red orthoclase felsite."[†]

The second citation is an observation of Mr. Huntington, who says of the porphyritic gneiss :

"The fact that rounded fragments of a dark gneiss are found in the porphyritic, shows that the porphyritic rock in Fitzwilliam is either intrusive, or that in the process of metamorphism, these fragments were not obliterated, and that the dark gneiss — which is very limited, but resembles some varieties of the Bethlehem gneiss — is the older rock."[‡]

Reference has been made to the evidence borne on the pages of the Vermont and New Hampshire reports, that the geological disorder reigning in those states is of the most perplexing character. Observations of strike and dip defy co-ordination, except within very limited areas. Many pages are devoted, in different portions of the second volume, to records of dip and strike, but no general tendencies to groups or systems of strikes is distinctly apparent.

[*] *Final Report*, ii, 668, 669. See further, pp. 98, 99, 102, 274.

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[*] *Proc. Amer. Assoc.*, 1872, xxi, 145.

[*] *Final Report*, ii, 472. See also, pp. 513-514.

I copy at random, for illustration, the records made of the dip of the rocks of the "Montalban series" in a single town, Grafton :

At McKelton's, S. 60° E., 72°.
At mica quarry, N. 32° E., 80°.
At west side, S. 50° E., 75°.
At north, S. 63° E., 70°.
At ¼ mile southeast of J. Martin's, S. 78° E., 70°.
At Alger hill, N. 62° E., 75°.
At H. Bullock's, S. 38° E., 50°.
At Prescott hill, N. 82° E., 40°.
¼ mile northeast of T. Foss', S. 65° E., 70.°
At Mrs. Arvin's, S. 62° E., 78.°
At Tewkesbury pond, S. 33° E., 75.°

Nevertheless, professor Hithchcock has given us, near the close of this volume, a chart of "Principal axial Lines of Vermont and New Hampshire." He says: "This is the final summing up of all the multitudinous observations of this report. * * This map and the statements of the last few pages are the key to Part II. They are the generalizations derived from our entire work, both in the New Hampshire and Vermont surveys."*

Turning to the chart, we observe a series of broadly sinuous lines drawn across the two states, having in western Vermont a general direction nearly north and south; in the eastern part of the state, a general conformity to the trend of the Connecticut river; and in New Hampshire, a still stronger tendency to a NNE direction, with some irregularities in the White Mountain region. These are simply lines of observed structure. We are told also, that at every point, they are the average of the different strikes observed. This is worth something; but geologists will be better satisfied, when, from this multitude of discrete data, some later hand, if not professor Hitchcock's, shall have evolved the deep historic and genetic truth concerning the sequence and vicissitudes of this puzzling complex of terranes.

THOMAS BENTON BROOKS.

1873. The progress of the investigation undertaken by Major Brooks under the auspices of the Geological Survey of Michigan, in 1869, was shaped by complete sympathy with the general views then prevailing; and those, it is just to say, were strictly Canadian. The Canadian survey had settled in the conviction that the iron-bearing rocks of the Marquette region were all of one age, and they were of the same age as the rocks north of lake Huron which they

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***Final Report.* II, p. 673.

had long known as Huronian. Thus the geologists of Michigan came into the traditional belief that the whole territory of the Northern Peninsula of the state was covered by the Huronian and Laurentian systems—save the recognized Lower Silurian angle at the east—the St. Mary's peninsula. Major Brooks, as the result of four years of investigation, concluded that the whole geology of the Marquette district above the Laurentian, might be embraced in a certain number of groups, which he designated numerically. As the characterization of these groups will be the best exhibit of major Brooks' views, and as these numerical designations are necessary matters of frequent reference among geologists, they will be at once presented.*

XX. *Granites* southwest of Lake Michigamme (Taken from *Wis. Rep.*, iii. 648.
XIX. Grayish-black *Mica-Schist*, often staurolitic, and holding andalusite and garnets, Rarely *chloritic schists*.
XVIII. (Doubtful). *Quartzyte* west end of Lake Michigamme?
XVII. *Anthophyllitic schist*, with iron and manganese.
XVI. (Uncertain.) Contains some hæmatite.
XV. *Argillyte.*
XIV. *Quartzyte*, often conglomeritic. Position immediately over the ore. Contains neither marble, talc nor novaculyte; very rarely argillyte.
XIII. *Specular and magnetic ore.* The principal bed.
XII. Banded, ferruginous, *Jaspery schist.*
XI. Coarse *dioryte*, with a light grayish and reddish feldspar.
X. *Silicious, ferruginous schists.*
IX. *Dioritic rock.*
VIII. Silicious, *magnetic schists.* "Flag-ores."
VII. *Dioritic rock.*
VI. Silicious, magnetic, banded, *chloritic schists.*
V. *Quartzyte*, sometimes containing marble (used as flux) and beds of *argillyte* and *novaculyte*. Very persistent. Very seldom conglomeritic.
IV. *Silicious, ferruginious schist.*
III. *Silicious, ferruginious schist.*
II. *Silicious, ferruginous schist.*
I. *Silicious, ferruginous schist.*
[The crystalline schists follow below.]

"These beds," he says, "appear to be metamorphosed sedimentary strata, having many folds or corrugations, thereby forming in

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*The table is compiled from the *Michigan Report*, Vol. i. pp. 85-116.

the Marquette region, an irregular trough or basin, which, commencing on the shore of Lake Superior, extends west more than forty miles * * While some of the beds present lithological characters so constant that they can be identified wherever seen; others undergo great changes. Marble passes into quartzite, which in turn, graduates into novaculite; diorites almost porphyritic, are the equivalents of soft magnesian schists. * * The total thickness of the whole series in the Marquette region, * * may aggregate 5,000 feet.

"Near the junction of the Huronian and Laurentian systems, in the Marquette region, are several varieties of gneissic rocks, composed in the main of crystalline feldspar, with glassy quartz and much chlorite. Intersecting these are beds of hornblendic schist, argillite and sometimes chloritic schist. These rocks are entirely beneath all the iron beds, seem to contain no useful minerals or ores, and are of uncertain age. No attempt is here made to describe or classify them." (p. 84.)

Of the "diorytes, dioritic schists and related rocks" he says: "These obscurely bedded rocks * * range in structure from very fine-grained or compact (almost aphanitic) to coarsely granular and crystalline, being sometimes porphyritic in character. * * On the one hand it graduates into a heavier, tougher, blacker variety, which is unquestionably hornblende-rock, with some feldspar. * * On the other hand, it passes into a softer, lighter colored rock, of lower specific gravity, which while it has the same streak, weathers similar to true diorite, is eminently schistose in character, splitting easily, and appearing more like chloritic schist than any other rock. (p.99.)

"At several points, dioritic schists, semi-amygdaloidal in character, were observed; and in one instance, the rock had a strong resemblance to a conglomerate." (p. 99.)

"At Republic mountain, a doleritic schist graduates into a black mica-schist," (p. 100). Dr. Hunt expresses the opinion that in the case of Marquette diorites the hornblendic mineral often becomes softened and hydrated, passing into a degenerate form more nearly allied to chlorite or delessite (in which water is an essential constituent) than to a true hornblende." (p. 101.)

"The bedding of the rocks is generally obscure, and in the granular varieties, entirely wanting. It is usually only after a full study of the rock in mass, and after its relations with the under- and overlying beds are fully made out, that one becomes convinced, whatever its origin, it presents in mass, precisely the same phenomena, as regards stratification, as do the accompanying schists and quartzites." (p. 102.)

Of magnesian schists, ("mostly chloritic,") he says:

"Intercalated with the pure and hard mixed ores at all the mines worked in formation XIII, are layers of a soft, schistose rock, of some shade of grayish-green, and often talcy in feeling. * * It is unquestionably a magnesian schist, varying from chloritic to talcose in character, and sometimes apparently containing a large percentage of argillite." (p. 104.)

"A very peculiar occurrence of this rock are the so-called 'slate-dykes,' which can be seen at the New England, Lake Superior and Jackson mines, but still better in the quartzite ridge just north of the outlet of Teal Lake."*

Speaking of the quartzyte (No. XIV,) he says:

"As if to leave in our minds no shadow of doubt as to the sedimentary origin of this rock, nature has, in addition to the conglomerate on the Spurr mountain range, given us a variety of the Upper Quartzite, which can only be described as a fine grained, friable banded sandstone." (p. 108.)

In discussing argillytes, he says, in addition to beds interstratified in the quartzytes:

"At least two distinct beds of argillite have been made out; one immediately beneath the ferruginous schist of formation X, to be seen in outcrop on the south shore of Teal Lake, near west end, and in the rail-road cut about one mile east of Negaunee. Another and far more extensive bed is XV, which forms the stratum next above the upper quartzite. Color usually dark brown or blackish; but where associated with the marble, it is sometimes reddish. It has a true slaty cleavage distinct from the bedding. * * Black, carbonaceous matter is often present." (p. 111.)

"Beyond the limits of the Marquette region, we find in the recently explored Huron Bay District, the finest clay-slates so far discovered in Michigan."† Within the Marquette district, he finds a carbonaceous shale more highly charged with graphitic material, "of a bluish-black color, but burns white before the blow-pipe, marks paper like a piece of charcoal, is soft and brittle, slaty in structure, and having a specific gravity of but 2.06."

"This rock has been found in the Marquette region only at two localities: 1. The S. C. Smith mine, T 45, R 25, where it seems to bound the iron ore formation on the northeast. 2. On the south side of Sec. 9, T. 49, R. 33, along Plumbago brook." Analy-

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*See this occurrence described by the writer in *XVI Ann. Rep. Minn.* p. 180.

†This shale is recognized as identical with that occurring west of lake Gogebic.

sis gave professor Brush 20.86 percent carbon. "The analyses prove the material to have no commercial value, but possesses scientific interest as proving the existence of a large amount of carbon in the Huronian rocks. The equivalency of these shales with the members of the Marquette series has not been established; they are undoubtedly Huronian, and are, I suppose, younger than the ore formation XIII." (116.)

Major Brooks reported also, in a condensed way, on the Menominee Iron Range (pp. 157-182,) and very briefly, on the Lake Gogebic and Montreal river Iron Range (pp. 183-6). In connection with the latter, he presents a section showing the unconformable junction of the (so-called) Huronian with the (so-called) Laurentian. This is the same unconformity as has since been pointed out by Sweet, Irving and others.[*]

1879. Major Brooks, in 1879, made further publication of his views respecting the Menominee region, and particularly, that part of it which extends into Wisconsin.[†] Of his earlier Michigan work he makes the following memorandum:

"My reconnoissance of the northeastern side of the Menominee, the results of which are given in the Geological Survey of Michigan, vol. I, 1873, gave valuable data; but that work on the whole, was incomplete and crude, and will be superceded by this report, which is, however, not complete in several directions."[‡]

He recognizes the "Keweenaw (copper series)" among the rocks of his district. The Huronian, he states, is "known to rest nonconformably on the granite and gneissic rocks, regarded as of Laurentian age." [He is here understood to refer to the Penokee unconformity.] As to the Huronian, he claims to have succeeded in determining, in the Menominee region, the equivalents of his numbered groups in the Marquette region; and it will be useful to reproduce the essential parts of his table:

XX. *Granite, gneiss* and *porphyryte.*
XIX. *Mica-schist, hornblende-schist* and *gneiss.* Black, subcarbonaceous *slate* and *chloritic schists.*
XVIII. (Not observed.)

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[*] *Trans. Wis. Acad.*, 1875-6, III, 43-44; *Amer. Jour. Sci.*, 1877, III, xiii, 308. This Whitney and Wadsworth call a "supposed unconformability" (*Bull. Mus. Comp. Zoöl.*, vii, 495, 496, 497), adding that "the proof advanced was, that the foliation of the granite and gneiss dipped at a different angle from that of the Huronian rocks." * * "They have failed to observe the phenomena of contact, when seen, beyond the mere fact of a different dip to the foliation observed." Such too frequent rude contradictions might with more courtesy have given place to expressions of doubt; but, with more justice, to expressions of respect for the authority of such excellent observers.

[†] *Geology of Wisconsin*, vol. III, Pt. vii, pp. 429-459, with appended microscopical observations by Dr. Arthur Wichmann (of Leipzig), pp. 600-656, and Appendices, pp. 657-663.

[‡] *Geology of Wisconsin*, iii, p. 431.

XVII. Gray *gneiss* with small crystals of triclinic feldspar, and large ones of orthoclase. Associated with hornblende-chloritic-and micaceous-*quartz-schist.* The Commonwealth Iron horizon.

XVI. Schistose *greenstone,* with micaceous, chloritic, quartzose varieties. *Dioryte* (gabbro?).

XV. (Not identified.)

XIV. Light-gray, specular, conglomeritic *quartz-schist,* containing mica and magnetite.

XIII–VIII. (Not identified.)

VII. Gray and red, soft, unctous, *hydromicaceous schist,* graduating into *clay-slate.*

VI. *Iron ore.* Banded, quartzose, ferruginious *schist.*

V. *Dolomite marble* with cherty laminæ. Very thick and prominent.

IV and III. (Not identified.)

II. Lower *quartzyte,* massive to semi-schistose, arenaceous, in places micaceous and actinolitic, with occasional specular ore. Felch mountain supposed in this horizon.

I. Chloritic *gneiss*; hydrous-magnesian *schist*; *slate-conglomerate*; *quartzyte* and perhaps *dioryte.* (Possibly Laurentian.)

Comparing the Huronian rocks of different regions, Major Brooks reaches the following conclusions:

1. The Huronian rocks are generally rich in species and varieties, but the maximum of varieties is found in the Marquette and Menominee regions."

2. "The points of resemblance between the Marquette, Menominee, Sunday Lake and Penokee series are so numerous as to point, I think, unmistakably to their having been formed in one basin, and under essentially like conditions."

He adds:

"Those who are not disposed to admit that lithology affords much assistance in identifying rock-beds over even small areas, should have in mind that the Lower Silurian sandstone can now be seen quite uniform in character, over a much greater area in the same region. Almost the same remark may be made of the underlying Keweenian rocks. Cannot approximately as favorable conditions have existed for the formation of a particular kind of rock over a smaller area at the earlier period?"*

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*Geology of Wisconsin, III, 449-50.

NEWTON HORACE WINCHELL.

1873. The second season of the Geological survey of Minnesota found professor Winchell engaged in an examination of the geology of the Minnesota river. In describing the outcrops of the "Granites of the Valley," * he noted some features which, in his later researches have proved to possess great significance, the older observers either not having noticed them, or failed to inquire under what conditions they have been produced. This granite is the common ternary variety. In the neighborhood of Granite Falls, he says, in his description, "there are sudden changes in the rock, from real granite to hornblende schist. These occur irregularly." He speaks of the formation as having a dip, and supposes it due to original sedimentation.

1880. The ninth annual report† of the Geological survey of Minnesota contains "A Preliminary List of Rocks," 442 in number, collected by professor Winchell, on a tour made during the season of 1878, from Duluth along the north shore of lake Superior, to Pigeon point, and thence through the interior by the line of lakes and streams marking the international boundary, westward to Vermilion lake, and still thence to the Mississippi river. Both portions of the route had been previously traversed—the line from Grand Portage along the boundary, by Houghton, Norwood, the Canadian geologists, and a long succession of traders; but no previous explorer had gone with so settled a purpose to penetrate the mysteries of the off-shore geology; and no one had made its study the chief end of his visit. Norwood was on a hasty reconnoissance over an extended line; Houghton made a brief excursion as far as to Mountain lake and returned; and Bell passed over the route chiefly for the purpose of reaching the Canadian territories about the Lake of the Woods. The tour of 1878 was somewhat carefully studied, step by step. Not only were rock masses investigated petrographically and structurally, but the plans of the contours of the country, the systems of their building up, the great obvious movements by which juxtapositions and superpositions had been effected—these fundamental phenomena were all taken in by a broad sweep of observation, and the problems connected with them, if not at the time resolved, were placed in the midst of surroundings which continued thereafter to throw important light on them. It is worth the while to note some of the observations made—at the time, apparently isolated, but afterward wrought

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Second Annual Report of Minnesota, 1873, pp. 160-176.
†*Ninth Report*, pp. 10-114.

into the great geological conceptions which seem now to represent much of the truth.

On the west side of Grand Portage, slate was seen which was probably the first recognition in Minnesota of the Animike formaion, isolated by Hunt in 1873, and of which so much was to become known. This is subsequently identified as the "silico-argillaceous slate" of Norwood. The "slate and quartzyte of Pigeon River Falls" are said to dip south. Numerous islands off the shore are visited. The principal rock-axis of Pigeon point peninsula, is, he says, "not evidently a dyke, but a massively bedded or coarsely jointed formation which extends west, and soon rises over fifty feet from the water, and shows a basaltic, mountain-like structure. It resembles the rock and structure of Rice point (near Duluth) and may be parallelized with it in age, and here is associated, as there, with a red, metamorphosed rock. Here, however, it is a part of the Animikie beds of Dr. T. Sterry Hunt, which would therefore seem to be only a downward extension of the Cupriferous series."

Proceeding as far as Mountain lake, he remarks "that these hills are all short monoclinals of gray quartzyte, with beds of argillaceous and black slate, dipping uniformly in a southerly direction, and covered with a greater or less thickness of the trap rock (gabbro?) of the country—the trap being sometimes one hundred feet thick, but generally less than fifty feet, and often the only rock seen, the lower beds being hid by the copious *talus*. The slate in some places has a dip slightly southwest, and the inclination amounts, usually, to about 8 or 10 degrees. The trap also dips with the slate, so that the hills have gradual slopes toward the south and steep slopes toward the north, or are perpendicular—indeed, they most frequently are perpendicular for about twenty-five feet from the top, or even one hundred feet, the trap having a widely basaltic structure, which causes it to fall away in perpendicular columns; the slate and quartzyte also, have frequent perpendicular jointage planes, which also facilitate the perpendicular breaking of the beds. The quartzyte is evenly and conspicuously bedded† without any confusion, but alternates, both gradually and suddenly with the black argillaceous slate. The most of it as far as seen to this place, is gray quartzyte. This quartzyte must be an immense formation, as it is that seen at Grand Portage, and all over Pigeon point, and the islands off the point."

**Ninth Report*, pp 69-70.

†The beds called here "quartzyte" are what the writer, in speaking of these formations, has styled interbeddings of "silicious (often jaspery) schist."

"Several important questions pertaining to the geognosy of this formation arise in an attempt to describe it, which must, for the present, remain unanswered, but which, perhaps, future examinations may solve :

1st. Is this trap older than the uplift of the hills, or did it come over the country when the uplift occurred?

2d. Are the dykes that are seen crossing this trap (as at the foot of South Fowl lake) of the same age as the trap, or are they subsequent to it?

3d. How much of the topography here is due to glaciation?

4th. Do the monoclinal hills run under each other, or are they each separate and isolated uplifts?

5th. Can these beds of supposed igneous rock be due to a change in the sedimentary rocks, instead of igneous outflow?

6th. Why is there an entire absence of amygdaloids?"

Arriving at the north side of Gunflint lake, he notes "hydromica (?) slate." "This rock rises in knolls and hills one above the other, irregularly disposed. The slates stand nearly vertical, running E. 20° N. This passes insensibly into the next," and "graduates back and forth." This resembles some forms of the slate at Thompson on the St. Louis river (p. 82). Belonging to the same formation is a "greenish, porphyritic rock (with albite ?), having an imperfect, schistose and fibrous structure, and some free quartz, embraced much like veins, in the slate. It is not vein matter, but gradually changes to the slate, right and left, the slates standing nearly vertical.

"This outcrop is supposed to belong to what the Canadian geologists have styled the Huronian. It underlies the quartzyte and Gunflint beds [now known as Animike slates] apparently unconformably. At least, it is another and distinct formation from the slates at Grand Portage" (p. 82).

It is to be regretted that this clew was not followed up. This is the discordance which has become celebrated.*

Coming to the characteristic black, silico-argillitic slate which gives name to Knife lake, he styles this rock "a light green, tough magnesian rock [which | can perhaps be designated a chloritic or serpentinous quartzyte," and recognizes it as belonging to the (then called) Huronian slate series; and thus, fourteen years ago, excluding it from the crystalline schist series, to which, later, it has been referred.

1881. A similar journey was made in 1879, and the results are found in the report for 1881.* The studies attending this trip were pursued under circumstances promising still larger results. The Knife-lake slates and the schists, now known as Kewatin, were identified near the west end of lake Superior. The tour extended to Grand Marais and Silver Islet, and from Grand Marais to Ogishke Muncie and the mouth of Poplar river. On Mayhew and Loon lakes he examined again, the "great quartzyte and slate formation, or the Animikie group." He describes again, and in more detail, the remarkably flinty breccia on the north side of Gunflint lake, and speculates on the cause of its condition.† I quote the following obscure paragraph:

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*Compare also, p. 102 at bottom, and notice the curious speculation, p. 103. It is evident from this that it remains to discover flint and jasper beds in the Kewatin.

"The close proximity of this flint and jasper locality to the next great underlying formation (syenites and slates)‡ makes it one of great interest to the geologist, but so far as scrutinized as yet, the true relations of the two formations are not revealed by anything here seen, though there seems to be an unconformability between them." (p. 88.) I have elsewhere quoted this passage as intimating an unconformity between the "slate and quartzyte" and the vertical schists north but further east, on Gunflint lake. But I am not sure this is the author's meaning, because he seems to be comparing the brecciated formation with the (underlying?) slates.

Coming to Ogishke Muncie lake, he subjects the mysterious conglomerate to further investigation. Notwithstanding the length of the passage, it may be well to quote largely, so that the reader may compare the statements with those of Sir William Logan in speaking of the slate conglomerate of Thunder bay (See p. 132.) He says:

"The conglomeritic character is hardly distinguishable on a fresh fracture of the rock, which sometimes shows different shades of green. But all over the surface, when glaciated and weathered, are visible the forms of rounded bowlders included in the rock, the different forms, colors and grain of the bowlders being brought out plainly. This is essentially the same formation as the rock 743 and 737, and it constitutes by far the greatest part of the country rock about Ogishke Muncie lake. Wherein the rock 737 differs from 738, which also passes into 744 by the accession of slaty structure, and the obliteration or modification of it by the accession of bowlders, it may be ascribed to varying proximity to, and influence of, the underlying 'talcose' rocks, in the process of deposition and metamorphism. * * On the island [Campers',]

Tenth Annual Report Minnesota, pp. 9-122.

†*Tenth Annual Report Minn.*, p. 87.

‡The breccia locality is *within* the slates of the "Quartzyte and Slate" formation.

it is a real conglomerate, with a smoothly glaciated surface, and the sections of some of the rounded stones are a foot, and even more, in diameter. They are very abundant. Sometimes the rounded stones make three quarters of the whole rock, but in other cases, the slaty matrix is nearly free from them, over considerable areas."

The author suggests the following order of superposition of the rocks in this part of Minnesota:

"1. The nearly horizontal quartzyte and slate formation composing the hills around the Grand Portage and the international boundary as far as Gunflint lake.

"2. The coarse grit or fine conglomerate, No. 738.

"3. The jaspery and calcareous beds that are known as the "Gunflint beds," Nos. 737, 743.

"4. The gray marble, No. 746. [See this further discussed in *XVIth Rep*. pp. 95–6.]

"5. The tilted slaty conglomerate, and the great conglomerate about Ogishke Muncie lake. Nos. 744, 750, 754.

"6. The amphibolyte and the chloritic slates, Nos. 731, 753, 348, 349, 350, 355, 356 and 358.

"7. Mica schists and alternations of mica schists and syenite. Nos. 335, 337, 339, 401, 406, 408, 414, 417.

"8. The syenites and granites of Saganaga and Gull lakes.*

"There is yet," he says, "one very important undetermined question relating to this generalized section, which ought to be borne in mind, viz: Is the great quartzyte and slate formation of the international boundary (No. 1 of this section) the same as the highly tilted slaty and quartzyte formation which passes into the great conglomerate (No. 5)? There are some considerations which seem to imply that it is, though in all descriptions and sections they have been treated as different terranes. (*a*) Where the horizontal slates approach the syenites at the east end of Gunflint lake, there is nothing to be seen of any beds representing the tilted slates. The syenites and their associated schists come on at once. (*b*) Where the tilted slates and conglomerates associated with them are traceable from the syenite upward to the gabbro, as south of Ogishke Muncie lake, there is nothing to be seen of any beds like the horizontal black slates of No. 1. (*c*) The "Gunflint beds" appear to belong to the horizontal slates of the international boundary at Gunflint lake, but their supposed equivalents[*] at Ogishke Muncie lake belong to schistose and tilted slates and conglomerates. (*d*) Although the horizontal slates and quartzytes of the international boundary strike west and southwest across the state, forming one of the most important topographical features of the northern part of the state, and can be followed for many miles as such, yet they are lost entirely in the region of the upper St. Louis, and the tilted slates are the only ones seen where that river cuts the rock at Knife Falls and below.[†] (*e*) The great gabbro belt which surmounts the horizontal slates along the international boundary, and prevails to the east and south of their line of strike, is seen to pass to the west of lake Superior, at Duluth, and to disappear from sight suddenly between Duluth and Fond du Lac, as if its continuance depended on the maintenance of the horizontal formation with which it is associated. (*f*) Where the Gunflint beds become jaspery hæmatite, as south and east of Vermilion lake,[‡] the structure of the tilted slates passes into the iron ore as if of the same formation. (*g*) The formation which underlies the Cupriferous at Fond du Lac is the tilted slates, and that which underlies it at Grand Portage is the horizontal slates."

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*I venture to make, on these assignments, the following suggestions:

1. This clearly is the Animike.

2. This, I judge, is only a border condition of the Ogishke Conglomerate (See XVI *Ann. Rep. Minn*, pp. 313, 315). There are also, on the borders of Frog-rock and Town-line lakes, several occurrences of gravelly sericitic schist—as also on Ensign lake. (XVI *Rep*. p. 312, Rock 863; and p. 315, Rock 889, 890.)

3. I feel constrained to regard these as no distinct part of the Animike. (See XVI *Rep*. p. 251.)

4. This is what is described as a bed of dolomyte in XVI *Rep*. p. 316.

5. The Ogishke Conglomerate.

6. By this I understand the author to mean the later-called "Kawasachong rock"—green chloritic slates (even if originally erupted); the "greenstone" hills south and north of Ogishke Muncie, and the chloritic and amphibolitic conditions of the "Kewatin" seen in many places.

No separate place is assigned here to the vertical schists.

These suggestions in a very perplexing inquiry, may be very wide of the mark.

"A thorough examination of the hill-range between Gunflint and Ogishke Muncie lakes would probably reveal the facts as to any transition from the horizontal slates to the tilted slates."[§]

From some confusion noted in the stratification of the region south of Ogishke Muncie lake, the author seems almost ready to adopt the alternative afterward embraced by professor Irving.

In a paper embodying descriptions of fifty thin sections prepared from the rocks of the Cupriferous series of lake Superior professor Winchell pointed out distinctly the two-fold origin of crystalline rocks. He showed by demonstrations accompanying the memoir,[*] that the crystallizations resulting from metamorphism sometimes imitate closely the character and composition of the rocks whose eruptive escape has been the cause of the metamorphism. On the north of lake Superior, the contact of the gabbro with the red sandstone has produced "all stages of metamorphic change — from red sedimentary shale and sandstone to red felsite and syenite." A sedimentary rock heated to the point of fusion of the feldspathic constituents, and then cooled, will exhibit a non-differentiated ground, with feldspar crystals porphyritically disseminated. Heated completely to the fusing point and then cooled, the least fusible mineral — probably quartz, would first crystallize out, and later crystallizations would be penetrated by the older quartz. Simultaneously, the intrusive matter would impart certain constituents to the softened sedimentary bed, and minerals would arise for which the requisite constituents had not before existed in the bed.[†]

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[*] It is not obvious that any such beds are there. But, in any event, if we distinguish the horizontal slates holding the "Gunflint beds" from the vertical slates holding the conglomerate, no difficulty will exist.

[†] From (*a*), (*b*) and (*d*), it is not to be inferred that two systems do *not* exist, but that they are not co-extensive. Their coëxistence is seen on the north shore of Gunflint lake

[‡] The very distinct hæmatite formation also contains jaspery beds.

[§] This journey was made in 1887. See *XVIth Rpcort*, pp. 79-80.

1884. At the Philadelphia Meeting of the American Association, he delivered an address before the Section of Geology as its president in which he discussed "The Crystalline Rocks of the Northwest."[‡] This was a broad survey in which he attempted to arrange the succession of the great Archæan terranes, and point out their relations according to the views of other geologists. As the table at the end contains a convenient synopsis of the positions taken that will be here first introduced.

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[*] *Proc. Amer. Assoc.*, 1881, XXX, 160-6. Also *Tenth Ann. Rep. Geol. Minn.*, pp. 137-143. The subject was earlier discussed in *Proc. Amer. Assoc.*, 1880, XXIX, pp. 422-425. Comp. also, Tenth Rep., pp. 108, 111.

[†] The phenomena here referred to are of the same character as those which professor Bailey has since described and explained. See *Amer. Jour. Sci.*, III, xxxix, 273-280, Apr. 1890.

[‡] *Proc. Amer. Assoc.*, 1885, Pt. II, pp. 363-379; *XIIIth Minn. Report*, pp. 124-130; *Amer. Naturalist*. xviii. 984-1,000. 1884; *Science*, iv, 230-240, Sep. 12, 1884 (abbreviated.)

GROUPS.	EMMONS.	HUNT.	BROOKS.	IRVING.	Equivalents in Michigan.	Equivalents in Wisconsin.	Equivalents in Minnesota.
GROUP I. Granite and Syenite with Gabbro.	Hypersthene Rock. (Regarded as part of the Primary.)	MONTALBAN. Labradorian. Norian Upper Laurentian. Aronian.	Youngest Huronian.	Base of the Keweenawan.	XX	I and Ia. at Black River.	Duluth. Brulé Mountain. Misquah Hills. Beaver Bay.
GROUP II. Mica Schist.			The	The	XIX at Marquette. XVII—XIX at Menominee.	XX—XXII at Penokee.	Little Falls. Pike Rapids. Outlet of Vermilion Lake.
GROUP III. Carbonaceous and Arenaceous Black Slate.	TACONIC SYSTEM, 1842-1846. Black Slate.	Animike.	Huronian	Huronian	XIV—XVII at Marquette. XV and XVI at Menominee.	VI—XVI at Penokee.	Animike. Black Slates. Grand Portage.
GROUP IV. Hydromica and Magnesian Slate.	Taconic Slate.		of Brooks.	of Irving.	VI—XIV at Marquette. VI—XI at Menominee.	IV—VI at Penokee.	At "The Mission" Vermilion Lake. Vermilion Iron Mines.
GROUP V. Quartzyte and Marble.	Stockbridge Marble. Granular Quartz Rock.	The Huronian of Canada, 1855.	1873.	1879.	V at Marquette. II—V at Menominee.	I—III at Penokee.	Ogishke Muncie Lake.
GROUP VI. Granite and Gneiss with Hornblendic Gneiss.	Primary.	Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.	Laurentian.

The author of this table comments upon his "Groups," in substance, as follows:

FIRST GROUP. Is represented in Minnesota by the gabbro and red syenite at Duluth. * * The outcrop of red granite near New Ulm, lying under the conglomerate and red quartzyte, is probably in the southwestward line of extension of this group.

SECOND GROUP. Consists of schists that are micaceous and often staurolitic as well as garnetiferous. Variously associated with beds and veins of granite and gneiss. Has a maximum thickness of 5,000 feet.

THIRD GROUP. Sometimes passes into roofing slates, with beds of iron ore, quartzyte and dioryte. "Includes the black slates of the Animike group in northern Minnesota, of Knife lake, Knife Portage on the St. Louis river; and carbonaceous shales lately reported near Aitkin on the Mississippi river. Thickness, 2,600 feet.

FOURTH GROUP. Schists soft and obscure, becoming quartzose and also hæmatitic; also with numerous beds of dioryte. In Minnesota, this is the iron-bearing horizon at Vermilion lake. Maximum thickness, 4,450 feet.

FIFTH GROUP. Represented by No. V. at Marquette, Nos. II. and V. at Menominee, and Nos. I. and III. at Penokee. The marble lies above the quartzyte, and in the Menominee region has a minimum thickness of 1,000 feet; while at Marquette, it graduates into a dolomitic quartzyte of indefinite extent, the whole group being there essentially quartzyte. A most persistent and well-marked horizon. The quartzyte sometimes holds feldspar, thus having the appearance of granulyte. In Minnesota this horizon seems to run along the south side of Ogishke Muncie lake, near the international boundary, and includes perhaps the great slate conglomerate which is there represented. This seems to correspond to the lower portion of the great quartzyte of this group, and to be the equivalent of the "lower slate-conglomerate" of the typical Huronian in Canada. Normal thickness from 400 to 1,000 feet; but if the great conglomerate of Ogishke Muncie be included here, the thickness of this group in northern Minnesota will exceed 6,000 feet.

SIXTH GROUP. In Minnesota, found on the international boundary, at Saganaga lake, and large boulders from it are included in the overlying conglomerate at Ogishke Muncie lake, showing an important break in the stratigraphy. Thickness unknown, but very great.

In the progress of the discussion, the author proposes to install the term "Taconic" in the nomenclature of the older rocks.

1887. The report of this year embodied views evincing positive progress in reference to several questions. The intimate relations of granitic rocks with terranes of admissibly sedimentary origin were brought into distinct view, and many instances of transition were pointed out,* and many remarkable cases of inclusion of granitic and gneissic fragments in the body of the schists, and vice versa. In the report, it was intimated that the Animike formation overlay one eruptive rock and underlay the other, and that it seemed to embrace the Ogishke Conglomerate in its lower portion (p. 381). The lower eruptive rock was represented to be, in some places, a remarkable agglomerate, and in various ways, to become changed to greenish schists, chloritic and sericitic, and to embrace in its mass, generally with an appearance of unconformity, the jaspilyte and iron ore of the Vermilion lake region. At the same time, this green rock exhibited, at times very manifestly, some signs of aqueous stratification. At other times, no such structure was found in it, and it merged into a dense, homogeneous, unbedded, doleritic mass. It was announced that the graywackes, which are in this "green-stone" formation, fade out by merging into its evidently eruptive condition; but in many places are distinctly sedimentary, having much quartz in rounded grains, arranged in unmistakable layers.

It was again pointed out that besides the large body of normal gneiss at the geological base of the series, there is inseparably associated with the gabbro, a red formation, having the apparent composition of syenite; and also a further distinction in the rock of the Giant's range — one portion of it being the result of local change in some bedded sediments probably later than the Laurentian (pp. 347, 349, 352, 353). The cause of this change in the sedimentaries was suggested to be the gabbro eruption. The red syenite resulting is the "red rock" of the earlier reports, the red quartz porphyry and the "Palisade rock" of lake Superior shore. This report contains a geological map of the northeastern part of Minnesota. The distinctions recognized are the following:

1. Trap and amygdaloid 2. Feldspathic sandrock	Cupriferous.
3. Gabbro and red granite, sometimes dioryte	Mesabi range.
4. Quartz porphyry and felsyte.	

**Fifteenth Annual Report Minn.*, 1887, pp. 290, 292, 293, 294, 296. See also, the accompanying reports.

5.	Gray quartzyte and black slate	Animike.
6.	Greenstone, diabase and chlorite schist.	
7.	Sericitic schist, argillyte and graywacke	Kewatin (in part.)
8.	Iron ore.	
9.	Conglomerate and conglomeritic felsyte	Ogishke.
10.	Mica and hornblende schist with dioryte	Vermilion series.
11.	Gneiss, syenite, granite	Laurentian?

1888. Questions of taxonomy and parallelism occupy much attention in the report of work for 1887.* A visit to the "Original Huronian" of Sir William Logan leads to the conclusion that while the stratigraphic descriptions of Logan were faithful, the "green chloritic slates," so-called, are not by any means constituent parts of the stratigraphy, but are distinctly eruptive. The "slate conglomerate" of Logan, he thinks repeated in Minnesota, in the Ogishke Conglomerate (pp. 39, 58, 59.) The general parallelism is given as below.

CANADA.	MINNESOTA.
Ottertail quartzyte Thessalon quartzyte	Pewabic quartzyte? New Ulm, Pokegama and Wauswaugoing quartzytes.
Black slate	Animike black slate.
"Lithographic stone" and fine gray quartzyte	(Not known.)
Red felsyte	Felsytes at Duluth, and probably the great Palisades.
Missisagui quartzyte	(Not known.)
Slate conglomerate	Ogishke conglomerate.

Careful observations reported from the region north of Gunflint lake, indicate two conclusions:

1. There is a gradual transition, structural and mineralogical, from the Kewatin downward, through mica and hornblende schist, to the gneiss (pp. 68-70. Also *XVI Rep.*, 37-39.)

2. The intermediate crystalline schists (Vermilion group) do not seem in all places to be present (pp. 74-77, 81.) Room exists for the supposition that the metamorphic action in some regions was sufficiently powerful to carry fused masses of the lower sedimentary rocks bodily across the stratigraphic horizon of the crystalline schists into contact with the Kewatin schists. For this reason, crystalline schists sometimes are interrupted by gneissic rocks.

Of conglomerates in crystalline horizons, he says:

**Sixteenth Minnesota Report*, 1888.

"The conglomeritic structure has therefore now been seen in the following crystalline rocks of Minnesota:

1. The Sauk Rapids "granite."
2. The porphyritic conglomerate at Ogishke Muncie lake, and the similar gneiss in Kekekabic lake.
3. The Stuntz island porodyte.
4. The greenstone of Twin mountain.
5. My brother reports it conspicuous in the Saganaga gneiss.
6. This bowlder [from Iron lake] shows it in the Vermilion group. (Later known in gneiss at Redwood Falls and Morton in the Minnesota valley.)
7. In the Laurentian syenite in Michigan, south of the Aurora mine.*

As to the distinctness of the Animike and Kewatin, the author entertains no longer any doubts, and he cites facts on pages 80 and 81 which prove it, and prove the equivalence of the Huronian of Canada with the Animike. But the upper part of the Ogishke conglomerate he is disposed to regard as a member of the Animike

In traversing the country between Gunflint lake and Ogishke Muncie lake he established the existence of an upper member of the Animike, which was named Pewabic quartzyte. It is magnetitic, and lies near the top of the Animike (pp. 85-86.) He parallelizes the Pewabic quartzyte with:

Wauswaugoning quartzyte.
Thessalon and Ottertail quartzyte (of Ontario.)
Potsdam sandstone of the Adirondacks.†

And these are regarded as further equivalents of the Pewabic quartzyte:

Granular quartz (Emmons)
Teal lake quartzyte, No. III (Brooks.)
Quartzyte group (Rominger.)
Baraboo quartzyte.
Sioux quartzyte (See XVIIth. Minn. Rep., p. 51‡.)

The following is the method of reasoning employed to establish the relations of the Ogishke conglomerate with the Animike:

"The hills about the northeast extremity of Gabimichigama lake consist entirely of Animike, fine-grained, tilted, fractured, recemented, but in general dipping northeasterly. At the lake shore, these beds weather out very rough, the silicious veins and the harder beds projecting. In some places they are about vertical, but they vary constantly in dip and strike."

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*Many bowlders may be seen in the granite of which the Chicago "Auditorium" is built. According to the writer's observation, few granites can be found without evidence of fragmental intermixture. The granite in the "Auditorium" was taken from the Giant's range, at Hinsdale, Minn.

†On this parallelism see, also, *American Geologist*, March, 1890.

‡In the eighteenth annual report he concludes that the Pewabic quartzyte is below the black slates of the Animike, carrying with it the great gabbro outflow and the red granites and quartz porphyries to the same stratigraphic position.

"In passing along the north shore westward, however, N. E. ¼ of sec. 31, 65-5, this rock becomes slaty and vertical, and strikes N. W. by compass.

"All along the north shore, from the northeast end of the lake to about the centre of N. E. of sec. 31, 65-5, these titled slates and quartzytes extend, having a high dip toward the northeast, and finally becoming vertical. The shore-line runs across the strike but not at a right angle. Hence in going west, one passes onto lower and lower beds. At this place the Ogishke conglomerate appears on the shore, rising in a ridge about fifty feet high, at a few rods from the shore. On the beach it is disintegrated and hardly preceptible. The dip of the beds of quartzyte and slate that are interbedded with it is 88° N. E. and the strike N. W. *There is thus seen to be an undeniable graduation from the Animike into the Conglomerate.*" (pp. 90-91).

Further evidences of a transition are thought to be present in the disturbed condition of the strata about Fox and Agamok lakes (pp 94-95).

1889. This result, as announced above, is pronounced in the report of work for 1888* an important point reached—"the separation of the Ogishke conglomerate from the greenstone agglomerate, on which in some places it must lie unconformably. They seem to have both been affected by the gabbro epoch of disturbance and the gabbro was found in different localities to lie on the greatly inclined strata of one, and the nearly vertical strata of the other."

This report embraces very comprehensive discussions of the "parallels of the Kewatin," the "possibility of rocks younger than the Kewatin, before the beginning of the Taconic," the "age of the Taconic (Animike Huronian)," and the "age of the Potsdam," all of which must be consulted in arriving at an adequate estimate of aggregate results reached by the author; but it is necessary here to avoid prolixity. Among "problems that need further investigation," the following themes are suggested: Eruptive and sedimentary Laurentian; Planes of hydrothermal fusion, and their relation to the origin of the crystalline rocks; Date of upheaval of the crystalline schists; Nature and origin of jaspilyte; What is muscovado rock ?

**Seventeenth Annual Report, Minnesota*, p. 24, 1888.

Toward the close of the report, the following general table of Minnesota rocks is introduced:

CALCIFEROUS. Magnesian limestones and sandstones. ST. CROIX. Sandstones and shales.	Dikelocephalus horizon.
Overlap unconformity.	
POTSDAM. Quartzyte, gabbro, red granite and Keweenawan.	Paradoxides horizon.
Overlap unconformity.	
TACONIC. Black and gray slates and quartzytes, iron ore (Huronian, Animike).	Olenellus horizon.
Overlap unconformity.	
KEWATIN. (Including the Kawishiwin or greenstone belt, with its jaspilyte), Sericitic schists and graywackes. VERMILION. (Coutchiching?) crystalline schists.	Archæan.
Eruptive unconformity.	
LAURENTIAN. Gneiss.	

CARL ROMINGER.

Dr. Rominger's observations and speculative opinions in reference to the older rocks are embodied in a state report upon the Marquette and Menominee iron regions of the Upper Peninsula of Michigan.* Taking up first the Marquette iron district, he conceives it "as a synclinal trough of granite, which by the upheaval of its northern and southern margins, caused the inclosure of the incumbent sedimentary strata between its walls, and their simultaneous uplift and corrugation into parallel folds by the lateral pressure exerted from its rising and approaching edges" (p. 4).

Speaking more specifically, he says of the two series hitherto regarded as Laurentian and Huronian :

By comparing the descriptions of the Laurentian formation as developed in Canada, with the granitic exposures observable in Michigan, or specially in the Marquette district, I cannot see so strong an analogy between them as to identify them without hesitation ; while I endorse the identification of the other group of rocks with the Huronian, although they differ too, in some degree" (p. 5). "I declare at once my serious doubts whether the granites of the Marquette region represent the Laurentian series of Eastern

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*Geological Survey of Michigan, Upper Peninsula, 1878–80, accompanied by a Geological Map, vol. iv, 8vo., pp. 248, 1881.

Canada, which I have never had an opportunity to study in the field, but which is represented to be a much older formation, preexisting as the surface rock before the Huronian sediments began to form, while, according to my own observations, the granites of Marquette are eruptive masses, which came to the surface after the Huronian beds were already formed."

Referring to the discordances between these two systems, frequently alleged by the Canadian geologists, he says:

"As far as my observations go, I have never been able to discover any positive proof of an existing discordance."

Further, in reference to the successional and structural relations of the series, he continues:

"By their eruption, [the granitic rocks] caused not only the great dislocations of the Huronian formation, but the half molten, plastic granite mass induced by their contact with the Huronian rock-beds, also their alteration into a more or less perfect crystalline condition, and commingled with them so as to make it an embarassing task to find a line of demarkation between the intrusive and the intruded rock-masses. The syenitic and gneissic hornblende rocks connected with the granite differ so little from the crystalline hornblende rocks of the Huronian series, that I look at them merely as differently advanced stages in the transformation of the same material. Those nearest to the focus of altering influences are now completely transformed and restored to the domain of the volcanic nucleus; the more remote strata were less changed, and retained distinct marks of their sedimentary origin; but if this view is correct, it cannot be expected to find traces preserved of the conformable or non-conformable deposition of the Huronian layers on their substratum" (pp. 6, 7).

He dissents from the subdivisions of major Brooks.

"Beginning below with his groups from I to V, he never made an attempt to define them. * * As to groups VII, IX and XI, certain dioritic outcrops are designated and considered to be regularly interstratified layers in the sedimentary succession, while I have full reason to consider them as intrusive masses, belonging to a lower horizon of the Huronian series, which by volcanic pressure have been forced through or between the incumbent rock-beds wherever a chance for it was offered, and consequently are found, one time in contiguity with this, another time with another stratum as it happened to be the surface rock of the spot. * * Groups XV to XX, intended to comprise a younger series of beds developed in the western part of the Marquette region, are unnecessarily multiplied into vaguely defined subdivisions. Major Brooks identified strata of the Menominee river district as representatives of Groups XV to XX which, lithologically, have no similarity with those of the Marquette district, adding still more to the confusion already existing." Dr. Rominger arranges the Huronian series in the following subdivisions (p. 8).

VI. Mica Schist Group.
V. Arenaceous Slate Group.
IV. Iron Group. [Quartzite Group (p. 71.)]
III. Quartzite Group. [Iron Group.]
II. Dioritic Group.
I. Granitic Group.

The Serpentine group is separately considered.

Before the completion of his report, Dr. Rominger became convinced that his Iron group and Quartzite group ought to exchange places, as shown above in brackets.

Besides the granitic masses bounding the Huronian on the north and south, he says:

"Granites are also found interstraified with the Huronian schists."

Of the character of the granite he says:

"They are usually middling coarse grained, of reddish tints, often composed of a magma of incompletely defined crystals imbedded within a granular interstitial mass rather than of well-formed, completely defined crystals; its fracture is therefore rather generally of a dull lustre. * * The micaceous constituent of these granites, where it does enter into the composition, is rarely well crystallized in brightly shining larger leaves, although it occurs occasionally, but usually has a minutely scaly form and a dark green color approaching to chlorite by gradations, or is replaced by hydromicaceous, fibrous, granular substance, generally called talcose from its soft greasy feel and its lighter color, with partial transparency in thin seams" (p. 15).

In describing gneissoid rocks of this region he says:

"This stratified banded rock, in contiguity with the granite, and alternating with it in parallel belts, often becomes completely entangled with it. The granitic masses intersect the gneissoid, enter wedge-like between them in the direction of the lamination or transversely, inclosing strips of the gneissoid ledges between the loops of the anastomosing granite seams, and, moreover frequently the so intermingled masses are curved into the most curious coils and serpentine flexions, which evinces their almost plastic condition at the time their intermixture took place." (pp. 16, 17.)

Passing to the consideration of the Dioritic group, and repeating his conviction that the granites are the newer, he says:

"One may ask, of what nature, then, was the substratum on which the Huronian sediments were deposited? I answer: Nothing contradicts the possibility of their deposition on a surface of granite already formed; it is even probable to me that it has been so; but, if we reflect upon the high degree of plasticity, and the almost perfect liquefaction which the concerned rocks subsequently underwent, and upon the dislocative forces causing the softened, and necessarily by this softening process, considerably altered, masses to intermingle almost chaotically, we can no more wonder that the traces of the originally existing former relative position of the rocks among themselves are greatly obliterated. The records of these periods in the history of the earth's crust, when oceanic sediments commenced to form, and fell back again within the grasp of the central fire-focus, as we can observe it in this case, are wiped out, and most likely all our efforts to ascertain the existing original conformity or discordance between such rocks will be in vain" (pp. 22, 23).

"The rock series comprised under the name of *Diorite Group* is made up by a large succession of schistose beds of a very uniform character, which are interstratified with massive belts of diorite differing in structure from the minutely granular, almost aphanitic condition, to a coarsely crystalline form, and being in chemical composition almost identical with the schistose beds" (p. 23).

Certain relations of the dioritic masses and contiguous schists are of interest:

"Often we see, as in the above mentioned instances, the schists adjoining a diorite mass completely entangled with it, in a mode which proves a high degree of plasticity of the diorite mass at the time intermixture took place. * * Although the general character of this large series of rock-beds is very uniform, as it regards the chemical composition, still, an endless number of variations in their structure is produced by the different degrees of metamorphism to which these once indubitably sedimentary rock-beds were subjected" (p. 34).

It will be remembered that major Brooks had admitted the existence of two horizons of iron ore. This was because at Negaunee and the vicinity, a quartzyte was found in a relation of infraposition to the ore-bed, while in most of the mines of the district, a quartzyte was seen reposing above the local ore-bed. These phenomena were supposed to indicate the existence of an ore-bearing horizon above the quartzyte and another below it. Dr. Rominger undertakes to prove that only one ore-horizon exists, and that the normal position of the quartzyte is above. Major Brooks was also under the necessity of assuming two quartzytes, Nos. XIV and V, the latter, or Teal lake quartzyte, being, according to Rominger, identical with the former, and its actual relative position being "the result of an overturn of the strata." (pp. 71, 72, 89.)

Lithologically, he adds:

"The quartzites covering the ore-bearing ledges are compact, dark-colored by hæmatitic pigment and by intermingled granules of martite. The inferior strata are almost regularly brecciated and intermingled with ore-fragments. In the pits of the Cleveland mine, south of the Houghton and Ontonagon Railroad, these brecciated quartzites are immediately underlaid by a fine seam of specular ore which itself, is on its surface, of brecciated structure. This ore-bed is underlaid by a series of light greenish or grayish colored, silky-shining, hydromicaceous schists impregnated with small martite crystals, which on their part, repose on the red, jasper-banded lean ores with inclosed seams of granular and slaty specular ore. In the pits north of the railroad, the quartzite is generally underlaid by chloritic schists inclosing locally quite large octahedrons of martite. Below them usually follows a valuable seam of specular ore, schistose chloritic beds again, and then mixed, jasper-banded, lean ores, with other interstratified seams of ore, partly in the granular form, partly as a slate-ore; lowest, resting on dioritic schists are, in the New York mines, fine-grained, silky-shining, dark, gray-colored argillites, charged with minute granules of martite more or less abundantly," (pp. 81-82).

The "*Arenaceous Slate Group*" of Rominger is generally incumbent on the quartzyte formation; but where this is wanting, it rests on the iron ore formation; and if this also is absent, it rests directly on the dioritic series. According to these statements a break exists between the epoch of the quartzyte, and that of the Arenaceous Slate (Compare also, pp. 113, 114, 115.) These strata appear sometimes as "a thick belt of black, fine-grained, slaty rock-beds, interlaminated with silicious sandy seams. * * Next south of these slates are high walls of massive, light colored quartzites in direct conformable contact with them," (p. 105).

In other localities, the group "consists of sandy, somewhat micaceous flagstones, or of finer-grained, banded, silicious rock-beds all more or less impregnated with protoxide of iron as a coloring-matter, and with granules of magnetite, (p. 108). Elsewhere they are clay-slates more or less silicious, (pp. 112, 113); or "black magnetic flags interlaminated with slaty and arenaceous seams," (p. 117).

At a locality in the valley of the Carp river this series has "in part, a conformable northern dip with the quartzites, but frequently also, a southern dip is observed; though the direct contact of the two formations" is concealed by Drift, (p. 106).

This Arenaceous Slate group occupies the surface over a large area on the north of the dioritic belt which abuts on lake Superior at Marquette; and over another area on the south of the dioritic belt. It is believed by Dr. Rominger to be of the same age as the slate formation in the district of L'Anse and Huron bay, between Marquette and Keweenaw point. *The thickness of the latter slates "is enormously great." In color they range from dark to blackish, are partly hard and silicious, of bedding and cleavage too irregular for roofing, but are also in part, regularly laminated, of an agreeable black color, and well suited for roofing, (vol. iii, p. 163). Locally, however, the Huron slates vary to "whitish-gray-yellow, red and brown." They possess all degrees of hardness. The cleavage appears often coincident with the sedimentation, but where the colored bands are preserved, they are seen to make an acute angle with the cleavage. The sedimentary dip is northward. The formation presents three divisions: An *upper* of lighter colored, variegated slates; a *middle*, of alternating slaty and arenaceous beds, with interstratified, larger, compact quartzyte belts of light color and partly blackish; and a *lower* division embracing the roofing-slates, (vol. iv, p. 130). The middle division is regarded as equivalent to the Arenaceous Slate group of the Marquette district. It is likewise an instructive coincidence that a higher horizon of iron-ore occurs in both regions, of which the Taylor mine is an example in the L'Anse district, and the Northampton and d'Alaby mines (north of the Champion mine) are examples within the Marquette district. The ore occurs above the black slates, which in the Marquette district are graphitic. These ore deposits are regarded as contemporaneous with that of the Commonwealth mine in Wisconsin† (pp. 130, 222-227).

The rocks of the Mica Schist group of Rominger are described as "a sub-porous ground-mass of very minute granules of white, translucid quartz in intermixture with a large proportion of bright-

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*Dr. Rominger's earliest observations on the L'Anse slates are found in *Geology of Michigan*, vol. iii, pp. 150-166. His later views are in vol. iv, pp. 129-130.

†This is the view of major Brooks, recorded ante' p 174. The reader cannot fail to compare the description of these slates and their accompaniments of quartz-schist and iron-ore, with the published descriptions of the Animike series. See, especially, ante' pp. 176-184. For further description of the Commonwealth mine, see C. E. Wright, *Geology of Wisconsin*, vol. iii, pp. 678-684. Compare also, Eagle mine, Wisconsin.

ly glistening black mica scales, and not rarely also, with chlorite" (p. 131).

The mica is sometimes silvery, and the schists are interlaminated with large belts of a more compact, minutely granular, sub-porous quartz rock, not so rich in the micaceous constituent, but often mingled with curved greenish crystals of actinolite.* In some conditions this formation reveals a distinct sedimentary striation (pp. 132, 133).

Dr. Rominger is not able to reach a satisfactory solution of the genesis of the Serpentine group.

"The hypothesis that the Serpentine formation is the product of local metamorphic influences on the dioritic series [by which it is surrounded], is very improbable, as the lithological character of the two contiguous rock-species changes abruptly." "The rocks occur generally in bulky, non-stratified masses which, if they ever originated from mechanical sedimentary deposits, are by chemical action so completely transformed as to efface all traces of their former detrital structure. They resemble a volcanic eruptive rock, forced to the surface in a soft plastic condition; and most likely heat was one of the prime agents in their formation, or else transformation in combination with aqueous vapors—which is suggested by the hydrated composition of the serpentine" (p. 135).

A study of the Menominee iron district led to the determination of the following groups of rocks (p. 182).

III. *Lake Hanbury Slate Group.* Dark-gray, slaty or schistose beds, with interlaminated quartzose belts. Thickness over 2,000 feet.

II. *Quinnesec Ore Formation.* In the *upper* part, light red, whitish or gray, hydromicaceous and argillitic strata. In the *lower* part, silicious beds richly impregnated with iron oxide in the amorphous, hæmatitic condition, or in the crystalline form of martite, with metallic lustre, and inclosing beds almost exclusively of martite granules. The valuable ore deposits. 1,000 feet.

I. *Norway Limestone Belt.* Light-colored quartzyte and silicious limestone, usually in part of a brecciated structure. 1,000 feet.

The rocks along the Menominee river are regarded as equivalents of the Diorite Group of the Marquette district, and decidedly *not* representatives of Nos. XV–XX of major Brooks.

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*Evidently this is not a proper "mica schist," but rather a micaceous quartzyte or a micaceous quartz schist. It can scarcely be compared with the "tender" mica schists of Hunt's Montalban, though the horizon is nearly coincident.

In general, the comparison of the Marquette and Menominee districts, in spite of Dr. Rominger's deprecation of tabular parallels, may be best shown by the following table (pp. 240-241):

	MARQUETTE.	MENOMINEE.
V.	Ore deposits of the Taylor, S. C. Smith, d'Alaby and Northampton mines. Actinolite schists above quartzytes of Michigammi and Spurr mines.	Commonwealth and related ores. Actinolite schists.
IV.	Quartzyte Group (Teal lake). Limestone in juxtaposition.	Quartzyte of Sturgeon river falls. Limestone separated by an interval.
III.	Iron Group.	Quinnesec Iron range.
II.	Dioritic Group. Intrusive Granites.	Diorytes and schists of Menominee river. Felsyte Porphyry, Pemenee Falls.

ROLAND DUER IRVING.

1877. In his annual report for 1874, made to Dr. I. A. Lapham, state geologist of Wisconsin,[*] the "Copper-bearing Rocks" were made by professor Irving, a distinct division in the geology of the northern part of the state, holding a position between the Huronian and the Potsdam sandstone. He showed also the existence of a synclinal axis in Wisconsin, in continuation of the great trough between Keweenaw point and Ile Royale.[†] He held, *first*, that the beds of the Copper-bearing series and those of the Huronian were once spread horizontally over one another, including the whole series of tilted sandstones on the Montreal river; they were disturbed by the same force, and receiving their present tilted positions at the same time, as evinced by the entire conformability of the two series. *Second.* The horizontal sandstones of the Apostle islands and the west side of lake Superior were laid down subsequently, and after an immense amount of erosion; and the sandstones of eastern lake Superior were formed at the same time. *Third.* The Copper-bearing rocks should rather be classed with the Archæan than with the Silurian.

The Baraboo and related quartzyte masses lying in Wisconsin, many miles south of the principal Archæan area, have been differently viewed by different geologists, some regarding them as of Huronian age,[‡] and others, as the representatives of the Potsdam sandstone,[§]—the Wisconsin sandstone so described, pertaining as they think, to a higher horizon. Professor Irving, as early as 1871, announced his conviction of their Huronian age; and in the Wisconsin report, he worked out the evidences with fullness. The quartzytes are differentiated from the contiguous sandstone by lithological characters and abrupt structural unconformability; and the only weakness in professor Irving's position is the lack of full proof that the sandstone is the true equivalent of the Potsdam.*

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[*] *Geology of Wisconsin*, Survey of 1873–1877, vol. ii, p. 47, 1877.

[†] This view was earlier set forth in *Amer. Jour. Sci.*, III, viii, 45–56, 1874.

[‡] J. Hall, *Geology of Wisconsin*, 1862; Irving, *Amer. Jour. Sci.*, III, iii, 93-99; *Geology of Wisconsin*, ii, 504-524; Chamberlin. *Geol. Wis.* ii, 248-256.

[§] Percival, *Annual Report Geol. Surv. Wis.*, 1856. p. 101; A. Winchell. *Amer. Jour.* [illegible] xxxvii, 226; J. H. Eaton, *Wiscon. Acad. Sci.*, Feb. 1871.

1880. The third volume of the geology of Wisconsin reveals his masterly grasp of the geological structure of northern Wisconsin, and of the genesis and history of the rocks which underlie the region. Here are presented in bold and confident outline, those interpretations, bordering sometimes on speculation, which characterized the leading discussions which occupied him until removed by an early death. His writings are so voluminous, however, that it will not be practicable to do more than set forth his positions on some of the great questions with which he grappled.

In reference to the nature and origin of the Laurentian rocks, which he fully parallelized with the Canadian Laurentian (iii, 5), we find him using the following language:

"The prevailing rock along the northern border [of the northern mass] is a dark gray to black hornblende gneiss, in which the hornblende has usually been more or less altered to chlorite. This alteration, when carried to any considerable extent, gives a greenish tinge and greasy feeling to the rock, and in cases of extreme alteration, there is a passage to a green chloritic schist. The associated granites are usually light pinkish-tinted to gray, and highly quartzose, a frequent gneissoid tendency showing their sedimentary nature," (iii, 6).

"The hornblende gneiss is always very plainly laminated, frequently highly schistose and the whole internal structure of the rock, as seen under the microscope, shows conclusively its original clastic condition. The granites are generally without such distinct bedding but appear nevertheless, to be true metamorphic granite. No eruptive granite, recognizable as such, has been observed. It is not possible, without overstepping the limits of our district, to reach any important generalizations with regard to the Laurentian series. It is evident enough that the rocks are of a true sedimentary origin, and that they have been folded in an exceedingly intricate manner," (iii, 93).

In still another place, professor Irving records views in this connection, which possess interest:

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*This equivalency has been earnestly contested in writings by N. H. Winchell, already quoted. See. anté. pp. 175.

"The term igneous, as used by Mr. Wright, who seems also to hold to the unwarrantable theory that the original rock of the earth's first formed crust would be granite, is one not applicable to any granites, since even in the case of the exotic kinds, the relation of the constituent minerals disproves a true igneous origin. The quartz of granite is always the last formed mineral, whereas, from its infusibility, it would certainly be the first to form in cooling from a state of fluidity. All the facts go to show that the intrusive granites are but sediments softened by what has been termed aqueo-igneous fusion, to a degree of plasticity sufficient to allow of their penetrating fissures in the adjacent formations. The intrusive or exotic granites and the metamorphic or indigenous granites have thus had about the same origin, and there are no lithological characteristics whatever, either microscropic or macroscopic, by which we can distinguish them in specimens," (iii, p. 194, note).

At a later date, professor Irving recorded his views as follows:

"This stratification [of gneiss], or parallel arrangement of its ingredients, is commonly believed to have been caused by the process of sedimentation, the crystalline texture now shown by the gneiss and all other crystalline schists being regarded as the result of a peculiar process of molecular arrangement known to geologists as 'metamorphism.' While it seems very probable that there is a great deal of truth in this view, the theories of metamorphism as they now stand, are very unsatisfactory. Many rocks which have been called metamorphic are plainly of an eruptive origin, and it seems not improbable that the same origin is to be attributed to some rocks with a strongly developed schistose structure." *

Of the Huronian system he remarks:

"Lying immediately against the Laurentian, and very sharply defined from it, we find, extending from the Montreal river westward for fifty miles, to lake Numakagon, a belt of schistose rocks which we refer unhesitatingly to the Canadian Huronian, and which are beyond question, the direct westward extension of the iron-bearing series of the Upper Peninsula of Michigan," (iii, 6).

The subdivisions of this belt are recognized as follows, (iii, 6):

5. Medium-grained to aphanitic, dark gray mica schists, with coarse intrusive granite. 7,985 feet.
4. Alternations of black mica slate with dioryte and schistose quartzytes, and unfilled gaps. 3,495 feet.
3. Tremolitic magnetite schists, magnetitic and specular quartzytes — forming the Penokee Iron range. 780 feet.

Geology of Wisconsin, vol. i. p. 352, 1883.

2. Straw-colored to greenish quartz-schist, and argillitic mica schist, often novaculyte. 410 feet.
1. Crystalline tremolitic limestone, at times overlaid by a band of white arenaceous quartzyte, and at times absent, the next formation above them coming into contact with the Laurentian. 130 feet.

As the identification of the Penokee series with the Huronian is still a subject of debate, professor Irving's affirmative reasons possess interest:

(1). There appears to be a direct continuation with the iron-bearing system of the Marquette region of Michigan; (2). The grand subdivisions of the Bad river [Penokee] and Marquette systems are strikingly similar;* (3). The Bad river and Marquette systems both show the same relation to the Laurentian and Keweenawan systems as found in the Huronian of Canada; i. e. are newer than the former and older than the latter; (4). The Marquette system is found in unconformable contact with the Lower Silurian red sandstone of lake Superior, and also in the Menominee region, is also found in unconformable contact with the fossiliferous Primordial sandstones of the Mississippi valley (iii, p. 7).†

The boldest feature of the views promulgated at this time, was the characterization of the "Keweenawan System," a step foreshadowed in 1877, and evidently meditated since 1874. This widely extended Michigan-Wisconsin system is thus described:

"It is a distinctly stratified system, but is in large measure made up of eruptive rocks in the form of great flows. These appear to constitute in Wisconsin, the lower ten thousand to thirty thousand feet of the system, apparently without interstratified detrital beds. Above these, we find the detrital beds increasing in frequency, until they seem to exclude the igneous rocks altogether; the upper portions for some fifteen thousand feet, being apparently composed wholly of sandstone and shale, with a heavy mass of conglomerate at base" (iii, 7).

These rocks in northern Wisconsin, form a true synclinal depression, and the Chequamegon bay lies within it, but crowded over to the northern side. The eruptive rocks of the system are chiefly of the augite-plagioclase kind—hornblende when occasion-

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*The stratigraphy of the Penokee Range is given in *Amer. Jour. Sci.* III, xvii, pp. 394-395 and *Geol. of Wis.*, iii, p 450, table, and in full detail in the same volume, pp. 103-166. On the "Mica Schists and Black slates," see Van Hise, *Amer. Jour. Sci.*, III. xxxi, 453-459, 1886. On the "Iron Ores" of the series, see Van Hise, *Amer. Jour. Sci.*, III, xxxvii 32-48, 1889. On their "Origin" see Irving, *Amer. Jour. Sci.* III, xxxii 255-272, 1886.

†This identification had been announced previously by Irving in *Amer. Jour. Sci.*, III, xvii, 393-398, 1879. Further on the "Divisibility of the Archæan in the Northwest," see Irving, *Amer. Jour. Sci.*, III, xxix, 237-240, 1885.

ally occurring, being always a paramorphic product of the augite. These eruptives, therefore present a marked distinction from the hornblende-bearing eruptives of the Huronian ; and belong to the Rosenbuschian categories, diabase, melaphyr and gabbro. The diabases, which are far the most abundant, occur in distinct beds of overflow, each of which (as first pointed out by Pumpelly and Marvine) is amygdaloidal above, and massive, often columnar below, with an intermediate zone, which Pumpelly designated "pseudo-amygdaloidal." The gabbros are coarse grained, and two varieties are distinguished, the most common being light to dark gray and perfectly crystalline, and the other being red and black mottled, or red and gray mottled, with some of the crystals dulled in appearance, or red-stained by iron infiltration (iii, 10).[*]

1883. In the progress of these studies, professor Irving devoted much attention to the subjects of paramorphic changes and secondary enlargements in the mineral constituents of rocks ; and while not by any means the first to bring these facts to light, he was foremost in extending our knowledge of them, and in illustrating their importance in the history of the rocks. He alludes to the fact that most of the older, dark basic, massive rocks have been called diorytes, because hornblende is joined in them with a triclinic feldspar, while augite seldom occupies the same place. But he says:

> "Precisely the reverse of this is the case, the diabases, in fact, being the common kinds, while diorites are everywhere rare. Moreover, in many diorites entitled to be so called by their content of hornblende as a chief constituent, this mineral has been proved to be merely a secondary transformation of augite, remnants of which are here and there to be seen in little cores." [†]

This, he says, is true of all the diorytes which he had studied in this section, and he entertained little doubt that the same would be found true of the diorytes described by Wichmann from the Menominee region. Hence he concludes that no dioryte as an original rock, has been found in Wisconsin.[‡]

The work on the Wisconsin survey having closed, professor Irving entered upon a great undertaking, under the auspices of the United States Geological Survey. This was the preparation of "a memoir aiming at a general exposition of the nature, structure and extent of the series of rocks in which occurs the well-known native copper of lake Superior." The transmission of this memoir bears date October 25, 1881, but the title page is dated 1883.[*]

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[*] This series of beds had in 1873 been named "Keweenaw Group," by T. S. Hunt, (*Trans Amer. Inst. Mining Eng.*, 1, 331-342) ; and in 1875, "Keweenawian," by Brooks. Later "Keweenian," the more euphonious form of the name, was proposed by Hunt (Harper's *Annual Record*, 1876). See *Geol. Wis.*, iii, 660. Removing superfluous letters, there remains "Kewenian," the best form of all.

[†] *Geology of Wisconsin*, vol. i, p. 345, 1883.

[‡] What is true in Wisconsin is very likely to be true also in Michigan.

This remarkable work is an amplification of views, and strengthening of positions relating to a newly recognized geological system which in the Wisconsin report had been defined as Keweenawan.[†] It is not intended to give any synopsis of this volume, nor to point out the excellencies of the treatment; but a few of its more important positions will be stated.

The Lower Group of the Upper Copper-bearing series of Logan —the "Animike" of Hunt—is excluded from the system; but the white and red dolomitic sandstones, in the peninsula between Black and Thunder bays, and thence to lake Nipigon, are included. The horizontal sandstones which form the south shore east of Bete-Grise bay on Keweenaw point, and westward from Clinton point, Wisconsin, are also included. The system, then, "consists of the succession of interbedded traps, amygdaloids, felsitic porphyries porphyry-conglomerates and sandstones, and the conformably overlying thick sandstone, as typically developed in the region of Keweenaw point and Portage lake, on the south shore of lake Superior," (pp. 24, 385).

The volcanic theory of the origin of pebbles forming the conglomeritic beds is combatted. This theory had been promulgated by Houghton in 1841, and Foster and Whitney, in 1850 and 1854.[‡] The system is demonstrated to be unconformable with the Huronian below and the Silurian above.

The possibility of a sedimentary origin for any of the stratified semi-amygdaloids[§] of the Agate Bay group of beds is "absolutely excluded by the completely crystalline interior texture, the highly vesicular character, the presence of unindividualized magma, the microscopic flowage structure, and the graduation of each bed downward into vertically columnar, non-vesicular olivine-diabase,

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[*] *U. S. Geological Survey*, Clarence King, Director. "The Copper-bearing Rocks of Lake Superior," 4to, pp. 464, with maps and cuts, 1883. [Being Monograph V.] A full digest of this memoir is contained in the *Third Annual Report* of the U. S. Geol. Surv. pp. 93-198. *Bulletin No. 23, U. S. Geol. Surv.*, 1885, pp. 124, by R. D. Irving and T. C. Chamberlin, is an important supplement to this memoir.

[†] This system is set forth in an elementary way suitable for the general reader, by T. C. Chamberlin, in the first volume of the *Wisconsin Report*, pp. 96-118, 1883.

[‡] Wadsworth also states that Foster and Whitney "remain the best and most accurate exponents of the geology of the country." (*Bull. Mus. Comp. Zool.*, vii *Geol. Ser.*, i. pp. 13, 131); and would thus seem to approve this leading position: yet, without noting his divergence from them, he says: "These conglomerates and sandstones show by the rounded and water-worn character of their constituent pebbles and grains, that they are beach deposits." (*id.*, p. 128).

[§] Noticed by N. H. Winchell, anté. p. 177, and called by Norwood, "metamorphic shales."

(pp. 138, 287)[*]. The forms of the "Sawteeth mountains" he refuses to attribute to faulting, and says:

"The case is just such as is found in every region of flat-dipping, hard rocks, and especially where softer layers are interbedded, as in this case," (p. 142).

He regards the dikes seen along the Minnesota shore as sources of the flows of the lake basin ; and antagonizes Dr. Selwyn's suggestion of activity through a single vent (p. 144). The "Palisade rock," he says, "is shown under the microscope, to be a quartz-porphyry, with no traces of a clastic nature (p. 187). The central mass of the Porcupine mountains is a quartzose porphyry unquestionably eruptive. Their structure has so much in common with that of the laccolitic mountains in southern Utah, that they might be supposed to owe their existence to an eruption of the porphyry of their central portions. * * But these mountains, he concludes, "owe their existence, in all probability, to a fold, the porphyry of the central portions being one of the usual embedded masses laid bare by subsequent denudation" (pp. 150-1).[†] He takes the position, and repeats it many times, that the so-called Animike slates are "beyond question, the equivalents of the iron-bearing Huronian of the south shore" (p. 157).

Of the "red rocks" so largely associated with the gabbro of Duluth, he says:

"They lie in it very irregularly, and form nothing like distinct belts, so far as I could make out. They may be seen in great patches hundreds of feet square, and surrounded on all sides by the gabbro, and again, as at the quarry near Rice's Point, in irregular series, from two or three inches to several feet in width. Much the most abundant kind of these red rocks is one which presents macroscopically a wholly crystalline texture and a pinkish color mottled with green. Pink feldspar facets, now and then striated, quartz, and a greenish mineral, may all be made out with the naked eye. Under the microscope, the rock is seen to be chiefly composed of reddened orthoclase ; greenish hornblende, quartz and magnetite are also present. The quartz occurs both in quite large patches, and again in little strings running through and through the feldspars, in the usual manner of secondary quartz. A number of these small patches of quartz lying near each other will polarize together, showing that they are part of one individual. Moreover, the same is true of the larger quartz areas, and numbers of small particles lying near them, so that all of the quartz is considered to be secondary. This secondary quartz is frequently scattered through the feldspars in such a manner as to present the appearance of graphic granite, and again it is arranged in irregularly radiating lines. Chlorite is often present as an alteration product of both feldspars and hornblende. No base finer than the rest of the rock was observed, so that the name should apparently be syenite" (pp. 270-1).

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[*] On *a priori* grounds, one might expect unindividualized magma to remain in sedimentary rocks when not completely changed.

[†] See detailed description, pp. 209-225.

Another variety of the "red rock" is described as true granitic porphyry. A rarer variety is a felsitic porphyry. These are all regarded as phases of the same rock.

In describing the Animike rocks in the vicinity of Thunder bay, lake Superior, he sums up by saying that they "consist of a great series, probably upwards of ten thousand feet in thickness, of quartzites which are often arenaceous, quartz-slates, argillaceous or clay slates, magnetic quartzites and sandstones, thin limestone beds, and beds of a cherty and jaspery material," (p. 379). He says also:

"Logan moreover, evidently took as Huronian, that part of the Animike group which 'occupies the coast for a distance of ten miles immediately below the mouth of the Kamanistiquia river, on the north side, leaning in a narrow strip, against the gneiss of the older series,'" (p. 379).

The Animike rocks are confidently identified with the rocks of the Penokee Range; but these latter, as has been stated, were with equal confidence identified with those of the iron-bearing series of Marquette. The Animike must therefore be the equivalent of the Marquette rocks. But Irving endeavored to trace some positive resemblances between the Animike and the rocks of Marquette; but without very convincing results, (pp. 385-6).

At this point the able author is seen to be on the brink of a broad fallacious inference. He takes up the consideration of the "Original Huronian," and correctly concludes:

"It appears to me very probable that the original Huronian of lake Huron and the Animike slates of Thunder bay, and thence southwestward to the Mississippi river, are one and the same formation," (p. 390).

This was the opinion first entertained by Logan;* but he subsequently associated those slates with the overlying Keweenawan. Then, as there was a lower, unconformable mass of slate conglomerates, he concluded to call those Huronian. Irving, however, while still holding to the Huronian character of the Animike,

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Report of Progress, Geol. Surv. of Canada, 1844, p. 20.

seems to have disregarded the vertical slate conglomerates, apparently because they graduate conformably into the crystalline schists and gneisses, and might be taken for a portion of that series —an unconformability between two systems supposed Huronian and Laurentian, having been noted at Penokee gap. Thus Irving held as Huronian what Logan held as a part of the Copper-bearing series; and Logan came to hold as Huronian what Irving took as part of the crystalline schist series. But when Logan based his description on what he now held to be Huronian and Irving overlooked, Irving thought them to apply to the iron series of Vermilion lake (as they readily did), and concluded that to be Huronian, though in truth the rocks graduated into the crystalline schists, while what he had rightly identified with Huronian on Thunder bay, was really an overlying and discordant series. But that discordance Irving had not yet discovered at any actual juxtaposition, and he devoted much effort to showing how two different formations of different dip and strike, might, at some former time, have approached each other with a common dip and strike, (pp. 392-4). In this state of the facts professor Irving feels himself in a dilemma when he reads Dr. Bell's descriptions of assumed Huronian rocks more remote from Thunder bay, and misunderstands Dr. Bell at the same time, as speaking of the rocks which *Irving* had correctly called Huronian. Nevertheless, Irving is able to convince himself that all the areas by anybody called Huronian, agree in such particulars as to justify him in sweeping them all into that category, (p. 395). Irving suspects indeed, that two groups of schists have been confounded by the Canadian geologists—"the iron-bearing schists of the Huronian and the schistose greenish phase of the older gneiss"—but he does not suspect that he has himself identified and confounded two other systems which, unlike these groups, stand in discordant mineralogical and structural relations to each other.

1885. The overlap of professor Irving's Keweenawan studies on systems of older date, was the prelude to a formal investigation of the Huronian system as a specialty. This was undertaken also, under the auspices of the Government survey, and was in progress at the date of his lamented death. But some preliminary papers appeared, from which we may learn the fundamental positions which he was preparing to defend.* In the first memoir, the following areas of older rocks are grouped together under the designation Huronian:

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*A first paper entitled "Preliminary Papers on an Investigation of the Archæan Formations of the Northwestern States," was published in the *Fifth Annual Report* of the U. S. Geol. Surv., 1885, pp. 175-242.

The Original Huronian.
The Marquette-Menominee Iron-bearing schists.
The Wisconsin Valley slates.
The Penokee-Gogebic Iron-bearing schists.
The St. Louis, [Minn.] slates.
The Chippewa Valley quartzites.
The Black River Iron-bearing schists.
The Baraboo quartzites.
The Sioux quartzites.
The Animike series.
Folded schists of Canada.

In the progress of a condensed examination of these eleven areas, professor Irving states more explicitly, what he intimated in his previous memoir, that the so-called "crowning overflow," resting on the Animike cliffs of Thunder bay and the regions to the southwest, is not to be regarded as one final overflow, but a succession of overflows, interbedded in a succession of slaty deposits.[*] He opposes sharply the position of Foster and Whitney, and later, of Wadsworth, that the iron deposits and associated jaspers are of eruptive origin (p. 192). The folded schists north and east of lake Superior, described by the Canadian geologists, since 1863, as Huronian, are admitted, at least some of them, in that system, but he says:

"We are immediately confronted with a structural problem of a good deal of difficulty, *i. e.*, the relation of these folded schists to the unfolded Animike series. Generally as the Animike series is traced toward its northern border, it is found to lie against a belt of granite and gneiss. This is so along the shore of Thunder bay, and thence westward to Gunflint lake, and it is true again at the Mesabi Range and Pokegama falls district, in Minnesota. North of this belt of granite, comes the belt of folded schists. The appearance thus presented is at first sight, one of general unconformity between the flat-lying Animike and an older series including gneiss and older folded schists."

This state of facts was in direct conflict with his theory that the Animike and the folded (vertical) schists are one. The reconciliation of the facts and the theory occupied his earnest attention. A hypothesis was proposed for this purpose.[†] He supposes "that the Animike rocks were once continuous with the folded schists to the north of them, and that they are now separated merely because of the erosion of the crowns of the folds between them, the close folding of the folded schists being supposed, on this view, to have been produced concomitantly with the broad simple bend which forms the trough of lake Superior. On this supposition, the unfolded schists of the north shore are compared with the unfolded Penokee of the south shore; and the folded schists of the national boundary, with the folded schists of the Marquette and Menominee regions. All are supposed to represent a great sheet of Huronian deposits once continuously spread upon a floor of far older gneisses and schists, which have since been brought to view by folding and denudation."*

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[*] P. 203. See also, *Fifth Annual Report*, p. 382. The "crowning overflow" is now discredited by the present Director of the Canadian Survey—*Science*, ii, p. 675, 1884.

[†] *Third Annual Report, Wisconsin Geol. Surv.*, *p. 171*; *Monographs U. S. Geol. Surv.*, vol. v, pp. 390, 417; *Fifth Annual Report*, p. 296.

Some little support for this not impossible hypothesis, was gathered from the fact, that in one region, where the horizontal and vertical schists were separated by only a few miles, the horizontal schists acquired considerable dip. In some localities, as shown by N. H. Winchell, they became irregular in dip, and manifestly disturbed. But professor Irving was never able to proceed further.†

In the sequel of this memoir, the author presents other results of studies upon his general problem, and among them are interesting facts respecting enlargements of quartz fragments (pp. 229-230); and these lead him to an explanation of so-called "crystalline sandstones". (p. 219)‡ A final conclusion from these studies is "that all of the quartzites marked provisionally as Huronian on the accompanying map, including the type Huronian of lake Huron, are merely sandstones which have received various degrees of induration by the interstitial deposition of a silicious cement which has generally taken the form of enlargements of the original quartz fragments, less commonly, of minute, independently oriented areas, and still less commonly, of an amorphous or chalcedonic silica, two or even three forms of the cementing silica occurring at times together in the same rock" (p. 236).

Fifth Annual Report, U. S. Geol. Surv.. pp. 206-207.

†The writer will here state that the Minnesota Survey has shown that the disturbances referred to (east of Ogishkemuncie lake) are very local, and the horizontal schists north of Gunflint lake are not separated from the vertical by a gneissic interposition, but rest in very discordant contact upon them. No more speculation is necessary.

Professor Irving read a paper before the *National Academy*, Apr. 22, 1887, which was published in *Amer. Jour. Sci.*, III, xxxiv, 204-216; 240-263; 363-374, entitled, "Have We a Huronian Group?" This was chiefly an occasion for restating the views presented in the paper here noticed, and for a final effort to elucidate his hypothesis for the synchronization of the Animike and the older schists now known as Kewatin. This paper has been noticed by me in *Bull. Geol. Soc. Amer.*, i. p. 387.

‡The subject has been more fully treated in *Bulletin U. S. Geol. Surv.*. No. 8, 1884. by R. D, Irving and C. R. VanHise.

Such enlargements in "Hornblendes and Augites" have subsequently been described by professor C. R. VanHise, *Amer. Jour. Sci.* III. xxxiii. 385-388. 1887.

The subject of enlargements of feldspar fragments is similarly discussed and the facts established.

A final conclusion from all the facts is that the most of the rocks generally styled Huronian do not properly fall under the head of metamorphic rocks.

These inferences are carried further in the important Bulletin cited above.

1888. The last important memoir from Professor Irving's pen is a compilation of fundamental principles to be employed in the classification of unfossiliferous rocks.*

Of this the author says: "Beyond many of the facts cited in illustration, and the mode of presentation, the paper does not contain very much that is new or original." It nevertheless presents a convenient synopsis of principles, and shows a mature mastery of the subject. For the present purpose a few quotations of new or maturing views on certain points, will suffice. Speaking of the green schists which with more or less of mica schists and other later rocks has been marked as Huronian for the entire region north of lake Superior by the Canadian survey, he says they are not separated from the Laurentian by any unconformity. Therefore, "The name Huronian belongs to an entirely different group."†

In attempting to illustrate the structural relation of the Animike series to the underlying schists, he presents (p. 421) a diagram section across Gunflint lake, which sets forth the observed facts with sufficient accuracy. But his interpretation of the fact seems to be erroneous. He says the Animike abuts "against an older formation of granite and schists," and he says too, "the iron-bearing horizon at the base of this succession [the Animike] is lithologically identical with that of the Penokee series of northern Wisconsin and Michigan." So far he is perhaps, right—but, with the understanding that the "granite" [gneiss] is quite removed from the *contact* with the Animike, and that the "schists" *at* the contact are not the usual crystalline schists which succeed the gneiss and granite, but hold a position superior to them, in the same vicinity. Professor Irving's misconception consisted in regarding those vertical "schists" as part of the series of crystalline schists, and in conceiving them as different from the vertical schists which inclose the iron ores at Vermilion lake. Identifying these vertically-standing ore beds with those in the flat-lying Animike, he makes

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"On the Classification of the Early Cambrian and Pre-Cambrian Formations. A brief Discussion of Principles, illustrated by examples drawn mainly from the Lake Superior Region." *Seventh Annual Report* U. S. Geol. Surv., 1888, pp. 363-454.

†Yet this is precisely the group which in the Vermilion region of Minnesota, professor Irving calls Huronian

an unsuccessful attempt to represent them as "flat-lying," like the Animike ores at Gunflint lake* (p. 421).

Professor Irving insisted on a "structural unconformity between the Huronian and Laurentian." He makes numerous references to Sir William Logan's utterances on the subject, and though they are strikingly self-contradictory, Irving asserts, they "show certainly his full belief in such unconformity" (p. 430). This confusion on Logan's part, and misapprehension on Irving's, arise from their common error in applying the name Huronian to two different systems, and Irving's supposition that the Penokee Huronian—rightly identified with the original Huronian—is the same as Logan's "Lake Superior Huronian."

In discussing the taxonomic exhibit which he gives of the older rocks (pp. 440-441) he says:

"At the base of the succession is a series composed of gneiss and granitic rocks, with also a large development of schists. The granite is certainly in the main eruptive. The schists are very largely compressed eruptives, but also in part of sedimentary origin" (p. 442). This view may be compared with those given, anté, p. 197.

But of the mica schists or mica slates described as holding a position near the top of the Marquette iron series, he says:

"Our own microscopical studies of them have demonstrated their derivation by mere metasomatic changes, from rocks wholly of detrital origin, the fragmental character frequently being well preserved, even to the naked eye, while large portions of the same horizon show little change from the original fragmental conditions." (p. 386.)†

As the outcome of the entire discussion, professor Irving resents the following taxonomic suggestion (p. 454):

Systems.	*Groups.*	*Systems.*
Paleozoic.	Carboniferous, Devonian, Silurian, Cambrian.	Paleozoic.
Agnotozoic or Eparchæan.	Keweenawan, Huronian, (Other groups?)	
Archæan.	Laurentian (including upper Laurentian.)	Archæan.

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* His diagram attempting this is in *Amer. Jour. Sci.*, III. xxxiv, p. 259.

† Such micaceous schists are what the writer, in the Fifteenth and Sixteenth Minnesota Reports, has styled "nascent mica schists."

ANDREW C. LAWSON.

1886. In his description and estimate of the rocks in the vicinity of the Lake of the Woods,* Dr. Lawson assumed positions of such originality and boldness as to entitle his contributions to an important place in this sketch of opinions concerning the older rocks of America.

The schists in the vicinity of the Lake of the Woods had been noticed by Bigsby and the other early explorers. By Bell, they had been designated Huronian, from their resemblance, undoubtedly, to the schists misnamed Huronian, on the north and east of lake Superior.† Dr. G. M. Dawson first remarked the apparent volcanic origin of a large part of the "Huronian" ‡rocks.

Dr. Lawson is not satisfied to embrace all the older schists in the Huronian.§ He says:

"The schistose belt of the Lake of the Woods appears to me to differ from the typical Huronian of Sir William Logan both lithologically and in other respects. The typical Huronian of Logan is, from his description of it, essentially a quartzite series, in which the quartzites are true indurated sandstones. The schistose belt of the Lake of the Woods is not so characterized. Quartzites form an extremely small proportion of the rocks of the Lake of the Woods, and then they are only local developments in formations of mica schist and felsite schist. Bedded limestones are characteristic of Logan's typical series. On the Lake of the Woods, there are, so far as I have been able to determine, no bedded limestones, the nearest approach to them being small segregated bands of dolomite of the character of veinstones. These two differences alone are sufficient to throw doubt on the equivalence of the two series, if lithological character is to be regarded as an aid to geological classification. There are, however, other differences. The basal conglomerate of Logan's Huronian, on Lake Temiscamang, is described as holding pebbles and boulders, sometimes a foot in diameter, of the subjacent gneiss, from which they appear to be derived. The boulders display red orthoclase feldspar, translucent colorless quartz, green hornblende and brownish black mica arranged in parallel layers, which have a direction according to the attitude in which the boulders were accidentally inclosed. The rocks on the Lake of the Woods, which are in the following pages referred to as agglomerate schists, are not basal conglomerates. They are not at the base of the series included in the schistose belt, nor are they apparently composed of water-worn fragments, derived from the rocks upon which they rest.

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*Report [illegible] special reference to the Keewatin [illegible] By [illegible] M.A. [illegible] Montreal, [illegible]

†R. Bell, [illegible] pp. [illegible]

‡G. M. Daws[illegible] parallel, 1875.

§The same [illegible] presented to the [illegible] Assoc., New York, [illegible] Results of a Field Study [illegible] Amer. Assoc. [illegible] 1888, p. 26[illegible] Amer. Assoc. [illegible] the Huronian [illegible] Amer. Geol. [illegible] March, 188[illegible] N. H. and H. V. Winchell, Proc. Amer. Assoc. [illegible]

"No fragments that can be referred to the underlying granitoid gneisses are found included in the agglomerate schists of the Lake of the Woods. All the facts connected with them point to a volcanic origin for these agglomerates, and the fragments are very frequently sharply angular, often with re-entering angles, although for the most part, they are elongated and lenticular in shape, as a result of pressure, and the paste in which they are imbedded does not differ from them materially, as a rule. In rare instances, they pass into a pebble or boulder-conglomerate, in which the pebbles are usually of a reddish felsitic material, and indicate the coëxistence of aqueous with volcanic deposition."

"The 'green slate rock' conglomerates at the mouth of the Doré river, lake Superior, described by Sir W. Logan, supposed by him to be equivalent to the rocks of his main Huronian area, appear to resemble the agglomerate schists of the Lake of the Woods. This Doré river area of 'green slate rocks,' is however geographically distinct, and appears to differ from the series in the typical Huronian region. The rocks are described as standing in a nearly vertical attitude, while those of the latter are comparatively flat. Neither are they associated with beds of quartzites or limestones to a material extent. Those differences, with the geographical separation, may, I believe, warrant us in considering the possibility of Logan having placed under one designation, two distinct series."

Other and good reasons are given for the opinions here set forth, but we must forbear to cite further.

" While thus the schists of the Lake of the Woods are older than the epoch of folding, and older than the granites which are intruded through them, Logan's typical Huronian has come into existence later than the time of folding of the gneiss, and possibly also, later than the main period of granitic irruption."

He refers to Irving's conclusions as supporting his own view. Citing Irving's full identification of the Animike series of Thunder

Thus, since the gneiss graduates into granite, he discovers a mineralogical graduation between mica schist and granite.*

Particular attention is devoted to the relations of the gneisses with the associated schists. "The gneiss", he says, "in some places, holds large and small angular fragments of hornblende schist . . The planes of *lamination* of the schist and *foliation* of the gneiss are parallel, though there are *unmistakable* evidences that the contact is an igneous one, and that when there is a mixed alternation of gneiss and schist, the former has been *injected* within the latter [italics are the compiler's]. This mixture of gneiss and schist, with occasional short broken bands and fragments of schist included within the gneiss, occur at intervals along the shore of Darlington bay" (p. 64).

In another place, he speaks of "dykes and gneiss" cutting the schists, and presenting the appearance of "evenly intercalated beds" (p. 72). As we approach the great gneissic area, these intercalations become more frequent. At the junction between the gneiss and schists, there is "no sharply defined line of contact, but a transitional series of layers of alternate gneiss and schist" (p. 72).

He gives figures of such alternations, and says:

"The two rocks [are] apparently interbedded as a transitional alternation, but the gneiss [is] in reality intruded." In one place he enumerates sixteen alternations of gneiss and hornblende schist, "some of the gneissic beds being as thin as four inches, six inches, eight inches and one foot, with intervening schistic beds as low as eight, twelve and fifteen inches, all regular and bed-like in their characters;" "but their true nature," he says, "as injected sheets or dykes, is sufficiently revealed." This opinion seems to be rested on the facts that occasionally a bed of gneiss sends "irregular tongues" into the schists, or includes "fragments of the schist walls."†

The plutonic view is defended by the author with unmistakable ability, (p. 83, etc); but we have not the space for adequate citations. The Kewatin is held, with reserve, to be structurally conformable with the Laurentian; but at the same time, it is presumable that a real historic break separates them.

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*Nevertheless, so far as the writer can ascertain, he regards the Kewatin as embracing all the rocks down to the gneiss, where, for the reasons given, he discovers evidences of a very different sort of geologic agency.

†Similar relations of gneiss and contiguous schists are described in the *Fifteenth* and *Sixteenth Annual Reports* of Minnesota; but a different interpretation is put upon the gneissic beds. See also the writer's memoir in *Bull. Geog. Soc. Amer.*, pp. 357-394, Apr., 1890.

As to the general structure of the region, he says:

"The granitic intrusions of the area of the Lake of the Woods may be grouped under ten main centres of occurrence or distribution, with a number of bosses of minor importance, which appear to be independent of these."

These areas are regarded as so many outbursts through the overlying Kewatin and are therefore of later age. The granitic masses have a definite relation to the stratigraphical structure, and seem to lie in the lines of folding, and to have been affected by the same cause as produced the folding (pp. 100, 101).

Of the Kewatin series he enumerates and describes the following members:

"Granitoid rocks at either extreme.

"Hornblende schists with associated altered traps, the whole more or less chloritic.

"Agglomerate schists, varying in character from greenstones to micaceous or gneissic schists.

"Quartzose mica schist, sometimes gneissic, but lamination very even.

"Hydromicaceous and chloritic schists, and arenaceous slates.

"Granite (irruptive)."

1887. In continuation of the results of his studies in the Canadian Northwest, Dr. Lawson gave a preliminary account of the geology of the Rainy lake region.* This region geologically is a continuation of that of the Lake of the Woods. He here brings out more expressly his belief that the granitic and gneissic rocks are younger in respect to the conditions in which we know them, than are the crystalline and semi-crystalline schists. He says truly:

"We do not yet know their original condition prior to the fusion from which they solidified into granites, syenites and gneisses. They may have been sedimentary; they may have been the original crust of the earth. But whatever may have been that original condition, the evidence is clear on this point, viz: that the fusion and solidification whereby they were brought into their present condition as firm crystalline rocks, took place at a period subsequent to the existence, in a hard, brittle condition, of the stratiform, and often very distinctly clastic, rocks which occupy the higher place in the column. Therefore, as rocks, the members of this fundamental system are of younger age than those of the nearest overlying formations."

But he draws the line of distinction between igneous and sedi-

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Amer. Jour. Sci., III. xxxiii, 473-480, June. 1887.

mentary rocks at the crystalline schists. He includes here certain fine-grained, bedded rocks for which he proposes the term "*granulite gneiss*."* The schists generally known as crystalline schists, occupying a position between the gneisses and the semi-crystalline schists, are here separated from the latter, and receive the name, "Coutchiching series."†

He says of them:

"They are very sharply and distinctly marked off from the lower granites and gneisses of the Laurentian. The geological contact between the Coutchiching series and the Laurentian is one of neither conformity nor unconformity. The break is of an entirely different order, and the contact is eminently that of an igneous injection or intrusion of the lower through the upper rocks" (p. 477),

The overlying [Kewatin] schists are "of entirely different character." The rocks are for the greater part "of volcanic origin' Though structurally conformable with the Couchiching series, the appearance of parallelism may be the result of folding and pressure. The diverse character of the rocks of the two series is proof of a profound alteration in the conditions of rock formation, which implies a geological break.

Regarding the systems in order of superposition, he arranges them thus:

Kewenawan (Nipigon).
Huronian (Animike).
Kewatin.
Couchiching.
Laurentian.

But regarding them in the order of age, they would stand thus:

Kewenawan (Nipigon).
Huronian (Animike).
  Diabase dykes and gabbro,
  Granite, post-Laurentian.
Laurentian.
Kewatin.
Couchiching

1888. Dr. Lawson's final report on the geology of Rainy lake region appeared in 1888.‡ This thoroughly scientific memoir, in the discussion of doctrines, is devoted rather to the strengthening of positions previously assumed than to the elimination of new views, and thus, in spite of its value, does not seem to demand more than the citation of a few passages. Among the facts however, which possess greatest interest, are some occurrences of a conglomerate which, as nearly as may be judged, is an extension of the Ogishke conglomerate of Minnesota.

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*This convenient and appropriate term has been used many years by the present writer. This, as also "granulite schist," are given in his "Geological Studies," pp 51 74, 76, etc. 1886.

†Better *Couchiching*, for reasons stated above.

‡*Geological and Natural History Survey of Canada.* Annual Report (New Series), vol III, Part I, pp. 182, with a map.

"On the shores of Rat-Root bay, the basal beds of the Keewatin are pebble-conglomerates, of which the paste is a green schist, and the pebbles mostly water-worn, rounded or oval pieces of vitreous or saccharoidal quartz. Some of the pebbles are feldspathic, and when so, are occasionally foliated. On the south shore of the bay, boulders of granite are observed to form part of the conglomerate, one boulder being at least eighteen inches in diameter, and of a roughly rounded shape" (pp. 38, 82, 105).

Again on Grassy lake, the basal beds of the Kewatin "are fissile, soft, green-chloritic and hornblendic schists, the detrital origin of which is established by the fact that on the north side of the lake, they constitute the paste of a pebble-and-boulder-conglomerate" (pp. 55, 82). This conglomerate is much more voluminous on the north side of Shoal lake.

Among the soft fissile, glossy gray schists of the Kewatin series at the west end of Schist lake, there are several beds of conglomerate, the pebbles of which are mostly quartz rock, and the matrix a soft, more or less calcareous, decomposed schist, stained yellowish with oxide of iron.

He notes the parallelism of the two series and says again, this affords but little evidence of original conformity; and relies upon the abrupt lithological contrast for evidence of a historical break. The conglomerate he regards as a *basal*[*] conglomerate "in which the pebbles have very probably been derived from the underlying formation" (pp. 56, 105).

He notes, what has also been observed in Minnesota, that the series of crystalline schists is quite inconstant in its occurrence. Sometimes the Kewatin rests on the gneiss, and then the basal member is likely to be hornblende schist. But this schist is apt to be wanting when the Kewatin rests on mica schist (p. 38).

Of the hornblende schists he says:

"There is much presumptive evidence in favor of the view that they are partly altered, massive rocks, and partly altered, volcanic ash-beds (pyroclastic), but little or none, that they are the alteration products of clays or other forms of detrital matter."

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[*] This position of the Ogishke Conglomerate of Minnesota has seemed to the writer clearly pointed out by the facts observed. See *Sixteenth Ann. Rep.* Minn. pp. 344-350; 359-360.

The changes undergone have been so profound that the original character has been destroyed, and a new rock of different constituent minerals has crystallized *in situ*. Pressure and crushing may have been potent in the destruction of the original structure; but in the later history, chemical or metamorphic forces have been chiefly active, and have obliterated all the traces of crushing (p. 73).

Of the soft, fissile, green schists he says:

"These are schists closely resembling the paste of some of the conglomerates. They are usually distinctly bedded. Their clastic origin can scarcely be doubted, though, as in the paste of some of the conglomerates, their association with bedded traps and their mineralogical analogy with the altered phases of those traps, renders it extremely probable they were never ordinary clays, but were originally fine-grained, volcanic ash-beds, the constituent minerals of which have suffered alteration and decomposition along the same lines as those observable in the traps" (p. 82).

He finds few serpentines. Their relations to the rocks adjoining them are ill-defined. They appear to be the alteration products of igneous masses which have the same geological age as the traps and other volcanic rocks of the Kewatin series; and although their common boss-like character suggests that they are intrusive through the Kewatin rocks, such intrusion has probably taken place coëval with the bedded formations, volcanic and sedimentary, of the Kewatin (p. 97).

In reference to the relations of the Couchiching series to the Kewatin and Laurentian, he remarks:

"Without being able to conclusively prove it, there appears to be much presumptive evidence in the facts cited, to show that the present eminently crystalline state of the Coutchiching series is the result of the metamorphism of strata which were originally in large part, ordinary quartzose sediment, although part may possibly have been acid volcanic rocks, such as quartz-porphyries or felsites. In many parts of the series garnets abound, and if the rocks were carefully examined, other metamorphic minerals would doubtless be found. That percolating silicious solutions were active agencies in effecting the metamorphism of these strata, is proved by the fact that in many places, particularly on the north side of Saginaw bay and east of Brulé narrows, the partings between the beds have served as fissures for the deposition of vein-quartz. This vein-quartz is very abundant in lenses or lens-like sheets, and is clearly a secondary product in the rock. The same watery solutions which desposited the quartz in these lenses, n the more open portions of the formation, must have saturated the rock throughout, and given rise, probably, to much of the quartz and feldspar in it. Only in one instance has hornblende been observed throughout the whole series. There are no intercalations of basic volcanic rocks, and none that can now be distinctly recognized as acid volcanic rocks. There are no limestones or dolomites in the series, nor have any conglomerates been observed." (p. 105.)

The subject of inclusions in the Laurentian gneiss is very particularly treated. These gneisses, both of the granite and the syenite type, frequently consitute a matrix in which angular fragments of schists are inclosed. These are most abundant in the vicinity of the lines of junction with the overlying schists. The included fragments may belong either to the Couchiching or Kewatin series. Along the zone of contact, apophyses or dykes from the gneiss penetrate the contiguous sheets. These facts are thought to prove that the inclusions are simply detached portions of the overlying formations "which in a firm and brittle condition, have become immersed in the underlying viscid magma, which subsequently crystallized out as the Laurentian gneiss and granite. It seems probable, too, that such shattering and detachment of fragments took place at the last stages of crumpling of the crust in this region. . . After the solidification of the Laurentian gneisses, there was no farther very violent deformation of the crust, for the Laurentian rocks appear to have resulted from the fusion not simply of the floor upon which the Coutchiching and Kewatin rock first rested—what ever such floor may have been*—but also with it of portions of those series" (pp. 130, 131).†

1890. Early this year, Dr. Lawson published a thoughtful and important memoir on the internal relations and taxonomy of the Archæan of Canada.‡ He discusses, first, the separability of the Archæan into two divisions, which, with subdivisions, would present the following scheme:

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*The recognition of the necessity of a "floor" on which the marine sediments could have rested, is a tacit admission of the existence of a geological formation older than that formed from the sediments. To say that we know nothing of that solid floor except as an inference, is the same as we must say about the former fused or plastic condition of the granites and gneisses. The indications of such plasticity afford no stronger basis for the inference than the indisputable necessity of a solid non-igneous sea-bottom to support the waters of a sediment-laden ocean. We have, in reason, in both cases, satisfactory ground for a conclusion, and in both cases, proof from observation is precluded. In fact, the conclusion that molten masses of granite emerged through or into beds of strata already existing, possesses the same kind of support as the conclusion that a solid foundation earlier existed for the penetrated strata to accumulate upon. It is, in short, demonstrable that the schists have no claim to be reckoned first in the order of time.

†Phenomena of the class here described have also been fully detailed, with many illustrations, from the contigous territory of northern Minnesota. See *Fifteenth* and *Sixteenth Annual Reports, Geol. Surv. Minn.*, 1886, 1887.

‡*Bulletin of the Geological Society of America*, pp. 175-194, March 20.

ARCHÆAN.
- Ontarian. [Now first proposed.]
  - Kewenian.* [Nipigon.]
  - Huronian. [Animike.]
  - Kewatin.* [Often confounded with Huronian]
  - Couchiching.* [Vermilion of N. H. Winchell.]
- Laurentian.

In presenting a petrographical description of the members of the Ontarian division he says of the hornblende schists:

"The field evidence points to their derivation from basic volcanic rocks," and cites examples from Norway and Scotland tending to prove "the derivation of the bulk of the hornblende schists from normal volcanic massive rocks, which were originally bedded with other stratified rocks, either as flows or as injected sills. Other hornblende schists are probably derived from an analogous alteration of tuffs of basic volcanic rocks" (p. 179).

As to the extent of the influence of metamorphism in the Ontarian system, Dr. Lawson offers reflections which narrow the gap between him and the metamorphic school. He says:

"In deference to these [plutonists] and other anti-metamorphic schools of thought, in which for the most part, theory seems to crowd out fact, it becomes necessary, with the accumulation of evidence of recent years, to point out the great additional strength acquired by the theory of metamorphism as applied to the Archæan by the recognition of the volcanic origin of much of the material upon which metamorphic agencies have operated, and by the limitation of its application to the upper division [Ontarian] of the Archæan; the rocks of the lower division, or Laurentian, being susceptible of an entirely different explanation. The lack of discrimination between the essentially different characters of the upper and lower Archæan, and the lumping of the whole complex together as having necessarily the same origin and development has been the great mistake alike of the metamorphic and the extreme plutonic schools. Just as the metamorphic theory, properly limited, affords the explanation of the development of the rocks of the upper Archæan from normal formations, so by a similar limitation of the plutonic theory, and the introduction of some modifying considerations, we will find in the latter, a rational and consistent explanation of the origin of the rocks of the Laurentian" (p. 181).

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*Kewenian is not named in this connection, but in previous documents it is put in the position here indicated.

Although this slightly simplified orthography of three of these divisions is here used by the writer, the terms are considered the same as those employed by Dr. Lawson.

In writing of the Couchiching series, for which the name "Vermilion series" was employed by N. H. Winchell about the same time as proposed by Dr. Lawson, he takes occasion to express regrets that the present writer had used "Vermilion series" and "Vermilion system" "in a much more comprehensive, but still undefined sense." It is proper to say that those expressions were not intended as taxonomic in value, but simply as geographical, referring to the whole assemblage of rocks about Vermilion lake.

In another memoir, Dr. Lawson has recorded[*] important observations on the pre-Palæozoic surface of the Archæan terranes of Canada. The surface known as *roches moutonnées*, generally attributed to the action exerted during the last glaciation, is seen to have existed when the Palæozoic sediments were laid down—formations of whatever age adapting their under surfaces to the bossy surface of the Archæan.

Another announcement possesses similar interest. Vestiges of Palæozoic strata are now known in so many districts resting in the protected depressions of the Archæan, that it appears probable that a large part of the Archæan surface was once covered by a blanket of fossiliferous rocks. In this view, the region which we call the Archæan nucleus of the continent was not visibly such until after a vast amount of denudation; though of course, it really existed as a grand swell in the fundamental structure of North America. A further inference from such a fact is the certainty that the material of the Palæozoic sediments was derived from some source now lost to view.

It becomes necessary to bring to a close our citations from the views of American workers on the nature and history of the older rocks. Though the undertaking has produced more voluminous results than were anticipated, there still remains a large body of valuable opinions, to which justice demands, probably, that some reference be made—opinions both of those who have been quoted, and opinions of others who, thus far, have been but incidentally mentioned. Regretting the necessity for these omissions, the compiler hopes, nevertheless, that what has been presented, may prove useful to many students in this difficult field of inquiry.

ERRATA.

Page 77—For "Bucoides" read Fucoides.
Page 83—For "It is intended" read It is not intended.
Page 108—After "Georgia trilobites" insert to.
Page 113—Dele "[4]" and five lines below substitute [4] for [5].
Page 126—Last line for x read plus.
Page 207—For "resents the following" read presents the following.

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[*] *Bull. Geol. Soc. Amer.* 163-174, March 12, 1890.

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